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The ADVANCEMENT OF SCIENCE

UNIVERSITY OF MICHIGAN
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Vol. XII, No. 47

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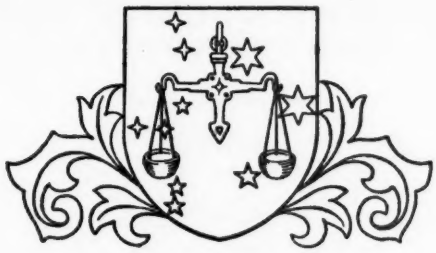
1831  1955

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BRISTOL MEETING

August 31—September 7, 1955

BRISTOL, with its rich and living traditions of culture and enterprise, its ancient foundations, its beautiful churches, its fine university and its historic city, made an ideal centre for the 117th Annual Meeting of the Association, and the fifth to be held in Bristol. The previous meetings were in 1836, 1875, 1898 and 1930.

It will long be remembered as one which was marked by gracious and generous hospitality, and by the notable efficiency of local preparations. The visiting members were also fortunate in that the Meeting coincided with the 800th Anniversary of the Granting of Bristol's first Charter by King Henry II in the year 1155, and they were privileged to take part in the city celebrations by attending a lecture delivered by Professor David Douglas in the Colston Hall on Saturday, September 3, on 'The Living Past.'

The Meeting was attended by 2,987 members, of whom about two-thirds were visitors and one-third were drawn from Bristol and its neighbourhood. Of this total, 2,095 were members or associate members, and 892 were student members, the majority of whom came from the universities and other centres of higher education. The visitors included many distinguished scientists from this country and from overseas, among them twenty-eight invited guests, including Professor Sydney Chapman and Dr. Lloyd Berkner, Chairman and Vice-Chairman respectively of the International Committee of the International Geophysical Year. The Association was honoured also by the presence of representatives of the Associations for the Advancement of Science from Ceylon, India, Pakistan, South Africa and the United States of America.

On the morning of the opening Wednesday, August 31, the City and the University jointly entertained the President, the Officers and the Overseas Guests of the Association at a reception in 'The Wigwam,' Red Lodge, after which the City and the University together entertained the Officers and certain members of the Association at luncheon in the University Reception Room.

The formal business of the opening day was conducted in the afternoon at meetings of the Council and the General Committee, which were held respectively in the Council Chamber and the Great Hall of the University. Sir Raymond Priestley, M.C., was elected President for 1956. An invitation to hold the 1958 Meeting in Glasgow was accepted with acclamation.

The Council adopted the following Resolution which had been submitted by the Conference on Land Use held at Exeter on July 16 and 17, 1955, under the auspices of the Division for Social and International Relations of Science of the British Association:

'That the British Association for the Advancement of Science represent to Her Majesty's Government the importance of arranging for the collection and publication of comprehensive statistics of the present use of all land in this country and of preparing an analysis on a national basis of the development plans now being submitted for approval in such a way that a balance sheet of land use may be drawn up. The Association submits that the collection of this factual information is a vital need in the present stage which town and country planning has reached in this country and in the formulation of national policies of land use.'

The Inaugural Meeting was held on the evening of August 31 in the splendid setting of the Colston Hall. It was preceded by a Graduation Ceremony at which the Vice-Chancellor of the University, Sir Philip Morris, C.B.E., conferred the Degree of Doctor of Science, *honoris causa*, upon Professor Sir Robert Robinson, O.M., F.R.S., and Professor N. F. Mott, F.R.S. After the Conferment of Degrees the Inaugural Meeting began with speeches of welcome by the Lord Mayor on behalf of the City and by the Vice-Chancellor on behalf of the University. The President,

Sir Robert Robinson, O.M., F.R.S., then delivered his Address on 'Science and the Scientist' (*Advancement of Science*, Vol. XII, No. 46, p. 137). He was thanked by Lord Adrian, O.M., P.R.S., the immediate Past-President.

Three evening discourses were delivered in the Colston Hall. Prof. C. F. Powell, F.R.S., spoke, on Friday, September 2, on 'Experiments at great heights with free balloons.' On Sunday, September 4, Prof. H. D. F. Kitto spoke on 'Scientific and dramatic modes of thought,' and on Monday, September 5, Mr. R. J. C. Atkinson spoke on 'Stonehenge in the light of recent research.'

There were also two afternoon lectures in the Colston Hall.

On Friday, Mr. R. A. Hamilton delivered an address on 'The scientific work of the British North Greenland Expedition,' and on Tuesday, September 6, Mr. B. J. Mason spoke on 'Man's influence on the weather: recent progress and future possibilities.'

In the days that followed, the Sections received over 300 communications on topics of current interest and importance, which included many papers on recent advances in research, as well as a number of critical reviews on a wide range of subjects. The Sectional transactions are summarised at the end of this number (*see* p. 355), and the texts of Sectional Presidential Addresses were published in the *Advancement of Science*, Vol. XII, No. 46.

The Sections were accommodated in the science departments of the University, the City Museum, the Royal West of England Academy, and the Bristol Grammar School. The arrangements were wholly admirable, and the Association is indebted to all those who co-operated so wholeheartedly and devoted so much of their time to so much detailed planning.

Numerous Sectional and general excursions were arranged. They were splendidly organised, and the hospitality of the many hosts was greatly appreciated by the members, who visited many places of considerable interest.

The general excursions included: Tours of the city of Bristol, excursions to Glastonbury, Wells, Wookey, the Cotswolds, Stonehenge, Avebury; and steamer excursions to Ilfracombe, Lundy, Mumbles and the Gower coast. A garden party given by J. S. Fry & Sons Ltd., at Somerdale, was greatly enjoyed by the 300 members who attended. The Mayor and Corporation of Bath also entertained a large party of members at the Pump Rooms after a tour of this historic city.

The Section dinners, which were well attended, were held on Friday and Monday nights.

The Reception Room, Administrative Headquarters, the Press Bureau and other offices, were situated in the Victoria Rooms. The Association has rarely had access to a building better suited and equipped to provide for all its needs.

The main social function of the Meeting was the joint reception given by the City and the University to the members of the Association, and which was attended by about 2,000 members in the University and the adjacent City Museum and Art Gallery.

On Thursday, September 1, the President held a reception for the Student Exhibitioners, which was attended by about 100 student members, and many of the Officers of the Association. At this reception he presented cheques to the winners of the Endeavour Essay Competition. The same evening the British Council held a reception at which overseas visitors were enabled to meet a number of scientists in this country.

On Sunday, September 4, Officers and members of the Association and representatives of the City and University attended an official Service in Bristol Cathedral. The sermon was preached by the Rt. Reverend The Lord Bishop of Bristol, and the Lessons were read by the General Treasurer of the British Association, Mr. M. G. Bennett, and by the President of the Free Church Council.

The City Museum and Art Gallery was open to members on the evenings of September 2 and 6, when they had the opportunity of seeing the extensive collections, illustrating local archaeology, British birds, entomology, geology and Egyptology, and the important Schiller collection of ceramics in the City Art Gallery. The members of the Bristol Naturalists' Society also arranged a special exhibition in the same building.

An organ recital was given in St. Mary Redcliffe Church by Mr. Garth Benson on the afternoon of Sunday, September 4.

Many members visited the Zoological Gardens as guests of the Bristol, Clifton and West of England Zoological Society.

Two interesting and important innovations at the Meeting were the exhibition of scientific work done by secondary schools in Bristol, Gloucestershire, Somerset and Wiltshire, and four papers read by school-girls and boys before members of the Association in the Assembly of Corresponding Societies. The Schools' Science Exhibition, which occupied seven rooms in the Bristol College of Technology, covered chemistry, physics, biology, and home science, and included both laboratory and field work contributed by boys and girls at all stages from first year to sixth form in over thirty public, grammar, and secondary modern schools; the last group being in the majority. This exhibition was a great success, and demonstrated most effectively the range of science teaching in the schools.

At previous meetings the last morning was devoted to a programme of scientific films arranged and organised by the British Universities Film Council. These programmes were so popular that the Council decided, on the recommendation of the B.U.F.C., to screen programmes of scientific films for several hours each day. The programmes were organised by Dr. A. R. Michaelis, the sessions were well attended, and this development was a great success. Members were also enabled —by the courtesy of the United Kingdom Atomic Energy Authority—to attend the first public showing of a film on Calder Hall.

The scientific members of the British North Greenland Expedition arranged a most interesting Exhibition which was accommodated in the Reception Centre, the Victoria Rooms. The exhibits were presented in a most attractive manner with the co-operation of the Royal Air Force, and showed something of the general life of the Expedition, which formed the background to the scientific work. A very large number of photographs were displayed; those in colour being particularly beautiful.

The President and other officers and members of the Council entertained the principal local officers and the overseas guests at dinner in the University on Tuesday, September 6. At this dinner the Vice-Chancellor, Sir Philip Morris, C.B.E., communicated the following message to the British Association from the Chancellor of the University, Sir Winston Churchill, K.G.:

'As Chancellor of the University of Bristol, I am glad that the British Association for the Advancement of Science is once again meeting in Bristol. The City and University will, I am sure, have taken good care that the arrangements for the meeting are excellent. I would like to have taken part as Chancellor in this 117th meeting of the Association, but unfortunately this was not possible. I have, however, heard good accounts of the success of the meeting, and congratulate all concerned.

'Science in the world of today is of very great importance, and I know well from experience what valuable contributions scientists have made in the service of this country and of humanity. I am glad nevertheless that some attention has been given during this important scientific meeting to the humanities, and especially to history.

'Will you please convey to the President, Council, and Members of the British Association for the Advancement of Science my best wishes and congratulations on the success of the meeting in Bristol in 1955.'

Professor Dr. O. Achmatowicz of Warsaw replied most charmingly to the Toast to the Overseas Guests.

A summary of the President's Address and other reports of the Meeting were broadcast in the Home Service programme of the B.B.C., and six special science programmes were broadcast by the Television Service of the B.B.C. during the Meeting. The proceedings of the Meeting were well reported during the week in the Press, and subsequently by *Nature*, *Discovery*, *Engineering*, and many other periodicals.

At their final session on Wednesday, September 7, the General Committee passed, with acclamation, the following Resolution of Thanks to all in the region who had done so much to ensure the success of another great Meeting:

'At the close of this eventful week, the General Committee, on behalf of all members of the British Association, resolves to place on record their deep appreciation of the warm

welcome offered to the Association by the City and County of Bristol, and by the University of Bristol.

'Aware that the invaluable local assistance has contributed so greatly to the outstanding success of the Meeting, the General Committee wish to convey the sincere thanks of the Association to the Lord Mayor of Bristol, the City Council and their officers and staffs, the Vice-Chancellor and staff of the University of Bristol and the Council of the Students' Union, the Local Secretaries of Sections, all firms and organisations in this great maritime and industrial region who have so freely offered hospitality, and all other hosts and colleagues by whose kindness and generosity the exacting requirements of the Association have been so abundantly met.'

AFFORESTATION AND THE COMMUNITY[1]

Address by

PROF. E. C. MOBBS, O.B.E.

CHAIRMAN OF SUB-SECTION K*

IT WAS only seven years ago, at the meeting of the British Association at Brighton in 1948, that the Chairman of the Forestry sub-section, W. L. (now Sir William) Taylor, delivered his address on 'The Influence of Forestry on the Community'[2]. Emphasising that this influence is material or economic, physical and psychological, and is exercised both through the living organism of the forest itself and through its products, he reviewed briefly the interaction between forests and mankind, from the Dark Ages to the present times. He showed how forests and trees had stimulated thought, the arts, and craftsmanship; how man had depended on forests for shelter, food, and materials for implements and weapons; and the value of forests in many parts of the world in preventing soil erosion; yet how man had steadily destroyed forests, to such an extent in Britain that less than five per cent. of our land is now under forest.

He then gave a brief account of the work of the Forestry Commission; the production of pit-props and timber, and the influence of our new forests on craftsmanship, trade and industry; the part they can play in helping to repopulate those large rural areas which have suffered from the drift to the towns; and their value for water conservation and for the preservation of our dwindling wild life. In conclusion, he referred to our National Forest Parks, the preservation of the 'amenity' of the countryside, and the educational, scientific and recreational possibilities inherent in our new forests.

This address, and the discussion which followed, particularly the papers of F. T. Brooks[3] and A. M. (now Sir Arthur) Gosling[4], served a very useful purpose in enunciating principles which, although fundamental to the forester, were not, and to a large extent still are not, appreciated by the general public.

In selecting a very similar title for this paper, it is not my purpose to deal again in a somewhat similar manner with forestry as a whole in relation to the community, but instead to look more closely at a few only of the aspects of this relationship, with particular reference to the extensive afforestation now being carried out in this country.

Firstly, there is the question of the extent to which the community generally appreciates what is meant by forestry, and is aware of how much afforestation has already been effected, and what is proposed for the future. There is still a great deal of ignorance on the subject. When I talk on forestry, whether at schools or colleges, to literary societies, guilds or other associations, I am almost always told by my audience that they had only very vague ideas about forestry before, and they have been really surprised to learn how much has been done in Britain, and what it all involves.

This general ignorance is somewhat remarkable. It is thirty-six years since the Forestry Commission was established, and in that time a whole generation has grown up. One might almost say, so far as appreciation of the work of afforestation is concerned, a generation of opportunity largely lost! One must, of course, acknowledge a certain slow but steady increase in knowledge, due to the publicity and propaganda work of the Forestry Commission, which now has its

[1] Address delivered on September 2, 1955, at the Bristol Meeting of the British Association.

[2] *The Advancement of Science*, V, 20, Jan. 1949, pp. 293–6.

[3] *Ibid.*, pp. 296–8. [4] *Ibid.*, pp. 298–9.

Publications and Publicity Officers ; but there still appear to be large sections of the population which have hardly been touched. One does not wish to carry the comparison too far, nor necessarily to emulate their methods, but one cannot help sometimes feeling that had such a bold and far-seeing programme of afforestation been initiated in certain other countries, had there been so much sound scientific and good practical progress as the Forestry Commission has achieved in the thirty-six years of its existence, it would have been accompanied by such a movement of education and propaganda, especially among the youth of the country, that in a single generation the whole population would have known a great deal about it and would have taken a justifiable pride in what its Forest Service was doing.

The principal ways in which publicity and propaganda have been carried out in Britain are firstly in a broadcast manner through the press, the radio and the cinema, by the sale or free distribution of publications, and by exhibits in agricultural and other shows ; and secondly, to a more restricted but more personal extent, by lectures, by organised visits to forests, and by special courses for schoolteachers and the adoption of forest plots by schools. All of these methods have been used by the Forestry Commission, mainly through its Publicity, Publications and Education Officers, but for the most part only to a very restricted extent. Some of the methods do not offer much scope for more extensive use, but others could possibly be considerably expanded.

There is such great demand from all sides for radio broadcast time, that one could not hope for more time to be allotted to forestry than at present, which includes only occasional feature programmes, usually on regional transmissions, and general warnings and instructions for fire prevention and control, in holiday seasons and times of severe drought. Similarly, there is probably little scope for expansion in the use of films in public cinemas. There is obviously a limit to the number of technical ' shorts ' that cinemas will take, and it is not easy to produce a variety of films on afforestation. Later on there may be a little more opportunity when extraction and utilisation are more developed, but for general use the scope of films will always be limited.

So far, the Press has paid comparatively little attention to forestry, although, apart from occasional outbursts against the Forestry Commission's methods or against afforestation in particular localities, it has in general supported the Commission. In the last forest year (ended September 30, 1954) the Information Section of the Forestry Commission was responsible directly or indirectly for something over 13,000 single-column inches of space in newspapers and periodicals. This total is the largest so far recorded, due to a considerable extent to the space given to the Grey Squirrel Campaign and to recruitment to various courses. But considering the vast number of papers and periodicals published and the size of some of them, this amount of space is really very small. A year's issue of a single daily paper runs into several hundred thousand column inches ; *The Times* and the *Manchester Guardian*, for instance, are equivalent to about 600,000 single column inches each per year, while the *Liverpool Daily Post*, a smaller paper, but with narrower columns, is almost as much. Further, much of the space given to forestry is duplicated in a number of papers at the same time and does not represent a steady stream of publicity. A press visit to a forest area or to a special forest function, such as the opening of a forest village hall, or the appearance of the Annual Report, may result in similar ' coverage ' in a large number of papers, followed by weeks or even months of silence so far as forestry matters are concerned. Also many notices, such as references to grants and to financial assistance for the moving of wind-blown timber, are not read by the general public ; and some of the articles on forest matters appear in technical or semi-technical journals, which have limited and rather specialist circulations.

While the Publicity Section of the Forestry Commission should certainly continue its efforts to stimulate the interest of the Press, it is doubtful that anything but a slow increase in the space given to forestry could be achieved. Something more is required, and I suggest that this should take the form of a new popular periodical, comparable possibly to *Forest*

and Outdoors, published monthly by the Canadian Forestry Association. Such a periodical could be published either by the Forestry Commission or by one of the Forestry Societies with Commission support.

There are already, of course, such periodicals as *Trees*, the quarterly Journal of the Men of the Trees, and the fairly new monthly *Country Fair*, besides the various older well-known papers, such as *Country Life* and *The Countryman*. But none of these quite 'fills the bill.' Had the Forestry Commission sponsored some such publication in the thirties, or even soon after the war in the later forties, concomitant with the creation of its National Forest Parks, and with the great extension of hiking, youth hostelling and caravanning throughout the country, it might well by now have captured the public imagination and built up a large circulation. Even now, I believe it is not too late ; there is still the need, and with a good editor who could enlist the co-operation of the Nature Conservancy, the National Trust, District Natural History, Botanical, Zoological and Ornithological Societies, besides foresters, biologists and sportsmen generally, there would be ample scope for the publication of such a popular magazine in Britain.

No doubt, the first reaction to this suggestion will be that it would not pay, especially as it would be necessary to pay most of the contributors. To begin with, it is not essential that it should pay. It should be regarded as part of the publicity work of the Forestry Commission. But I see no reason why before long it could not be made to pay well, especially if linked up on the one hand with the public enjoyment of the new national forests, the nature reserves and the National Trust areas, and on the other hand with the teaching of biology in schools.

The value of the more restricted but more personal forms of publicity would still remain. There is always a considerable demand for talks and lectures to schools, societies and institutions of all kinds, especially if they can be given without charge. If they can be followed up by visits to forest areas, their value is very greatly enhanced. While acknowledging the work done in this way by the Publicity Officer and by officers of the Conservancy staffs and Directorate offices of the Forestry Commission, and also by a few forest owners and other private individuals, there is, I consider, scope for very greatly increased activity.

It does not need to be emphasised that the lecturer should be an expert at his task, not rigidly bound to a fixed set of notes, but able to vary his lecture according to his audience. So easy is it to lose interest by the indifferent lecture, that I suggest this is a matter the Forestry Commission should take up more seriously than hitherto. An officer who has shown himself to be a really good lecturer for audiences of all types and ages should be put on special duty for this purpose, his services being offered free to schools, colleges, societies and institutions of all kinds all over the country. He should attend talks and lectures given by other Commission officers, with the object of spotting other good men, who should then be given time and opportunity to lecture in their own conservancies as part of their official duties. The time might well come when each conservancy would have its own official lecturer, whose main duty would be education and propaganda in this way. Each lecturer should have his own collection of slides and films, preferably made from his own photographs, or from photographs of areas with which he is personally acquainted, taken expressly for him. These he could supplement to a limited extent by films borrowed from the collections of the Forestry Commission, the Timber Development Association, or one of the Forestry Societies.

Taking the long view, the most effective way of educating the public is to concentrate on the children. To ensure that the next generation shall appreciate to the full our growing forest estate, it is essential that the youth of the country should be brought up forest minded. For this something more than spasmodic lectures is required. It is, I think, highly desirable that knowledge about forests and forestry should be taught in all schools.

The immediate reaction of the educationists is to oppose anything that savours of the addition of another subject to an already overloaded curriculum. Nothing

is farther than this from my intention. I suggest that the school syllabus for biology should be revised at all grades to give greater prominence to the study of trees, forests and forestry. Biology in one form or another is now taught in practically all schools, and in many of them to all children up to a certain age, while all the universities include biology in their lists of subjects which may be offered in the General Certificate of Education examinations. But usually very little attention is paid to trees or forests. The fairly lengthy and detailed syllabus for the G.C.E. biology may contain only a single reference to a wood as an alternative to a pond, the sea-shore or other area for a study of the relation of an organism to its environment; and generally it is not the wood that is selected.

During the past eight years I have interviewed a large number of candidates wishing to enter the University to take a forestry degree, many of whom have taken biology in the old School Certificate or Higher School Certificate examinations, or at the Ordinary or Advanced Level for the General Certificate of Education. Except in those cases where candidates have actually worked in forests to prepare themselves for entry on a forestry course, I have generally been amazed at their poor knowledge and often almost complete ignorance about trees and forests. They have studied unicellular organisms and filamentous algae, Hydra, earthworms and frogs; they know about permeability of membranes and cell division, reflex action and the nervous system; and they have often made a detailed study of the community of life in the pond at the other side of the school field. But in general they seem to know little about trees and next to nothing about the vast community of life that constitutes a forest. Yet already a million acres of forest have been established in this country by the Forestry Commission, in addition to the million-odd acres that already existed and the areas planted by private enterprise, and more millions of acres are planned for the future.

The study of trees, botanically and silviculturally, and of forests as communities of living organisms can be used to instil scientific principles just as much as the study of microscopic organisms and other plant and animal life included in the biology syllabus. It would mean a difference of emphasis and possibly the sacrifice of the study of certain basic principles, both botanical and zoological, but I suggest that to the average boy or girl it would be likely to be more useful in later life. From the more general point of view, even an elementary knowledge of forestry would introduce a great variety of other valuable instruction, from simple mensuration to utilisation, industry, national policy, and law. Here is scope for education in its widest sense, as well as opportunity for the study of the fundamentals of life.

Various objections will at once be raised to my proposal, but that they can be overcome has already been shown in those few schools where forests and forestry are given more prominence than normal—schools which have adopted forest plots and whose teachers have attended forestry courses. One objection will be that for most schools the field and the pond are much more readily accessible than the forest. This should not now be an insuperable difficulty. There are state or private forests in all parts of Britain, and with modern arrangements for school transport, school excursions, journeys and camps, and the integration of teaching in town and country, some forest area could probably be found for study for nearly every school. It is not suggested that forests and forestry should be the sole object of biological study, but that they should be given a more prominent place in the syllabus, and that to the extent required for this arrangements should be made for visits to forest areas.

Where schools are situated within reasonable reach of forests, the adoption by them of forest plots would follow as a natural course. There is already an adoption scheme, which a number of schools have taken up, but the possibilities have so far hardly been touched, and such success as has so far been achieved has been due to the enthusiasm of a few people. There is the danger that interest in adopted plots may slacken if there are no forest operations to be carried out. Plots should therefore be sufficiently large and with sufficient variation of crop to ensure

that there is always something to be done ; or alternatively, as in one forest I visited in Germany, the school might take up a series of plots in succession, while keeping one small area only for permanent scientific studies.

Where distance or other considerations make the adoption of a forest plot difficult, it might be possible to arrange for children to spend a few days as a school journey in a camp in a forest, where, in beautiful surroundings and combined with recreation, they could learn something about forests and perhaps actually take part in forest operations. Each conservancy should have at least one such camp, fully equipped on the lines of the better-equipped youth hostels, established and maintained in co-operation with all the educational authorities in the conservancy. These should be continually in use by parties of children from schools all over the conservancy. During the Easter and summer holidays, it might be possible to have selected senior children at the camp as special junior fire wardens. Experience elsewhere with permanent camps, with youth hostels and the like, has shown that such camps need not be expensive ; but they would require organisation and supervision. On the forestry side, this duty would perhaps best fall to the proposed conservancy lecturer and propaganda officer, who is likely to find his time very fully occupied.

This brings us to the second aspect of the relationship between afforestation and the community that I wish to consider more briefly, namely, the enjoyment of our new forests by the people. Youth hostelling and hiking, which have increased so much in recent years, have undoubtedly come to stay, and with the extension of holidays with pay for almost everyone, more and more people are coming annually to our countryside. The Forestry Commission has in general maintained an open door, except where plantations are young and particularly susceptible to damage. It has also established several National Forest Parks, and has published special guide books for them. This policy has undoubtedly been most wise. It is good to see our new forests growing up with no ' Trespassers will be Prosecuted ' signs, and while appreciating the sanctity of private property and the need for seclusion on account of game, one wishes that more of the private forests in our country could be made similarly accessible.

It has already been found necessary in some areas to close forest roads to the ubiquitous motorist, both in his own interest, due to the insufficiency of parking and turning places, and because of the liability of hindrance to extraction works. It must be accepted that such restrictions will become increasingly necessary as exploitation of the forests develops. But it is to be hoped that with the increasing number of roads and rides now being constructed, a few will be planned in some of the larger forests to be permanently available to motorists. These should have adequate turning and picnicking places, the latter being at good beauty spots and viewpoints. As the trees get taller, there should be no hesitation in sacrificing some to keep the vistas open.

Although there are certain disadvantages in having too many visitors in a forest, it is to be hoped that it will not be found necessary to close any to holiday-makers and others who enjoy a forest walk. On the contrary, I suggest that the Forestry Commission follow the practice adopted in certain Continental resorts and indicate by small paint-marks circular walks in some of our larger forest areas near holiday centres—' Follow the blue marks for the three-mile walk, the red marks for the six-mile walk,' and so on. Such marks need not be unduly bright, large or numerous, and they need in no way spoil the general beauty of the area. As a forest gets older and the trees bigger, the general topographical features of the area tend to be masked, and with the increasing complexity of the forest roads and rides, the ordinary holiday-maker would appreciate the marking of circular walks to guide him, and they would probably greatly add to his enjoyment of the area.

I suggest also the publication of a popular series of guides for some of the more frequented areas. These should be more restricted in the area covered than the National Park Guides ; for instance, one might cover the Gwydyr forest as distinct from the whole of the Snowdonia National Forest Park ; another might

cover the Lyndhurst area of the New Forest. Others might cover areas not included in a National Forest Park. These guides should be somewhat more popular in appeal than the National Forest Park Guides, and should have large-scale sketch-maps showing the various marked circular walks. The National Forest Park Guides are an excellent series. Complete with map, they give information on the history, the antiquities and the folk-lore, the topography and geology, the flora and the fauna of the parks, together with general notes on walks for hikers and the more energetic visitors, and other information. But I suggest that some of the guides at any rate are a little too technical for a large section of the general public. There are many who do not know what is meant by the Triassic Period or Silurian strata, who cannot interpret a geological map or section, and are put off by lists of plants, complete with Latin names in italics, but unaccompanied by any diagrams that would help to distinguish one plant from another. The more popular guides would be intended for these people rather than for those who can appreciate the excellence of the National Forest Park Guides.

The only other suggestion I have to make regarding the enjoyment of our forests by the public is that possibly organised excursions might sometimes be arranged, conducted by a forest officer—our proposed conservancy lecturer, for instance—for parties staying at holiday homes, such as those of the Holiday Fellowship, the Co-operative Holiday Association, and so on. These usually have a fortnightly series of excursions, and might possibly welcome a conducted excursion through forest areas in their programmes.

The third aspect of the relationship between afforestation and the community which I shall consider is its effect on the rural community in so far as forest labour is concerned. A fundamental point is that forestry employs considerably more men per acre than the hill farming, usually sheep farming, which it often replaces, and much of the afforestation work has been carried out in those sparsely populated rural districts which are the very ones that have suffered from depopulation in the past. As the forests develop into the full cycle of exploitation, it is estimated that they will provide employment for at least one man per fifty acres. For the million acres so far established this will mean 20,000 men, and when the afforestation programme is complete the number will be three times as great. If one takes into account all the ancillary occupations, in the timber trade and woodworking industries, for public services and local servicing trades, the total number of people ultimately dependent on the forests, even in the rural communities, may well be greater than this estimate.

The Forestry Commission is therefore faced with the problem of building up new forest communities ; from the outset it has had to import labour into sparsely populated areas, and these men and their families have needed houses, distributive services, education, transport and recreation. Up to the end of September 1954, the Commission had provided 4,387 houses for its staff, of which 619 were for foresters and foremen, and 3,768 for forest workers. Work was in progress on another 191 houses.

One of the first decisions which the Commission had to take was whether to house its workers in new villages, which would be convenient for forest operations, or in existing villages, which would be convenient for public services and amenities. Both methods have been adopted, but in large forest areas the Commission has tended to create its own villages within the forest, rather than face the cost of transport and loss of work-time that would be incurred if its labour were in existing villages more distant from the centres of work. This has not been without opposition, and the Forestry Commission has been accused of ignoring both the sad experience of the coal industry and the advice of county planning committees and local authorities in this respect.

Certainly, there are strong arguments against the establishment of new villages, especially where there is an existing one within reasonable distance. So far as national economy is concerned, it is argued that the building of a new village, complete with its own access road, water and electricity supply, drainage and sewage-disposal plant, is likely to be more expensive than spreading the cost over a larger

number of houses in an expanded village. Neither the new village nor the existing one is likely to be big enough comfortably to provide the support needed for schools, bus services, shops, a cinema and a ' pub,' nor to provide the capital for a church, a village hall, playing fields, etc., where these do not already exist ; whereas the combined population might be able to do this. The existing village is likely already to have at least the basis of that mixture of trades, professions and social classes which results in a balanced and lively community. The new village, on the other hand, is one of tied houses, dependent on a single industry with ultimately a single master.

There are, of course, arguments on the other side. The cost of transport and loss of work-time have already been referred to. It is very important also to have labour resident in strategic centres to be readily available in case of fire. Then it is often forgotten that imported labour usually comes from fairly large towns, and it is very difficult for a stranger from a town to get accepted in a conservative village community on the one hand, or to adapt himself to the method of life and traditions of that community on the other. He is a transplant that has great difficulty in developing the roots necessary for a successful life in an existing community. In some localities there has been some hostility between the indigenous farming community and the Forestry Commission, especially where it is alleged that some farmers have been displaced and labour has been attracted from others. This does not add to the popularity of the forest worker, and possibly the fact that some of the local authorities were dominated by farming interests may have both contributed to the Commission's policy of creating its own villages, and to the antagonism to it.

Whatever may be the reasons, antagonism in some cases still continues. In one case recently the chairman of a local authority is reported to have argued that since the life of a certain forest village would inevitably be short, there was no point in spending much money on services for the village. Time will erase, and is in fact erasing, the antagonism, but it will take much longer to cure the fundamental disadvantages of single-industry villages.

One of the most disturbing features of the new forest villages is the continual coming and going of tenants, and in some cases also the difficulty of filling all the houses. In the last annual report of the Forestry Commissioners (for the year ended September 30, 1954), it is stated that ' In Wales, relettings of forest workers' houses have been unusually numerous.' This is an important factor also in some other areas, although possibly less so than in Wales. In the report the reason for this is given as ' probably due to some townspeople being unable to adapt themselves to a new environment.' This places the emphasis on the degree of adaptability of the new villagers, and does not consider the environment to which they are expected to adapt themselves. What is briefly termed ' the environment ' involves a large number of factors. It would not be possible to attempt to analyse or even to list all these factors, even if I were competent to do so, which I am not, but I should like to examine a few of them so far as the forest villages are concerned.

There is the village itself. The Forestry Commission, having decided on its policy, very commendably went to one of the best known town-planners of the day. The result has been that the village layouts are mostly distinctly urban in design. Some of them appear to be governed by a theoretical conception that people who have worked over a widely scattered area would wish to be tightly packed in terraces when they come home, or possibly that this is the desire of the women, who do not go out to work in the forest and spend most of their time at home. The design of the houses compares with that in many modern ' estates,' and in general with rural council building, but the general impression one gets is of a small suburban estate transplanted into the forest rather than of a village.

Unfortunately, these miniature estates have often been built without shops, ' pubs,' halls, churches and so forth. These amenities have appeared in beautiful perspective on the master plans. No-one expected them to be built all at once, but it has, I think, come as something of a shock to the inhabitants when they have

finally realised that these amenities were not going to be provided automatically by the Commission.

The lack of shops is a very important factor, and although this is slowly being remedied, it is likely to be serious for some time to come. Travelling shops are appreciably dearer and the selection of goods more restricted than in fixed shops. The result of this, to take a single instance, is that housewives are finding it cheaper to take the long train journey from Kielder to Hexham, thirty-four miles away, and buy a stock of provisions there, than to buy from the vans that come to their doors. This is a serious matter, especially when the men are on minimum wages. Moreover, shops would provide a little employment for women.

The demand for employment for women and girls is already considerable. Quite a number of women would like to earn 'a bit extra' themselves, and jobs like school-cook, school-cleaner, and even carrying around the milk for a farmer, are viewed with envy and not lightly given up. But such jobs are few ; also, women with little children, and many of the new arrivals are such, cannot leave home easily. These would like piece-work, part-time employment, which they could do at home. This is practically impossible to find in a forest village. Some woollen mills in urban areas give out a certain amount of finishing work to women in the town or in neighbouring villages, but more often than not this is skilled work, and the women may have been trained to it by work in the mills before marriage. The rather miscellaneous newcomers to a forest village are usually unskilled, and it is doubtful whether any firm of repute would consider putting out work in a forest village unless it were really desperate for more workers, and even then it would have to train them first. For this, they would need a population that had steadied itself and had stopped 'shifting around.'

As the children grow up, the problem of their employment becomes almost a dominating factor. Most folk are concerned for their children, not wanting to see them have to leave home and start life on their own as early as fifteen years of age. The situation concerns particularly the girls, but in some cases the boys too. Not every boy wishes for, or is suited to, forestry work ; and also, where there are empty houses to fill, it is obviously better policy to engage married men as forest workers, who can occupy the houses, than to engage boys. Where there are several girls in a family, it is understandable that the family should plan to move to a place with more local openings. At the latest, such a move might be expected a year before the eldest girl reaches school-leaving age, so as to give the family a year in a bigger centre to settle down and look around and *choose* a job near home for the girl.

Various suggestions have been made to help solve this problem. One, for instance, is that a large sanatorium might be built in the healthy surroundings of hills and forests, within reasonable reach of a forest village. This would provide work for girls as maids and cooks and office staff, and some light jobs also for boys before they got into the heavier forestry work. The establishment of light industries is frequently suggested, although rarely is any concrete suggestion given as to what types of light industries might be suitable. No new light industry is likely to settle in a forest village until its investigators can report a steady and suitable source of the labour it needs ; and it is difficult to get a steady population till there *is* such extra industry. This is one of those vicious-circle conundrums.

The Forestry Commission should, I think, offer both workshop space and housing for key-workers for the establishment of industries, particularly those employing female labour. Either the Commission or the local education authorities should cover some of the cost of training the initial workers, and in some cases also it may be necessary for the Commission to subsidise industries during an establishment period. As the villages grow, the Commission should encourage local servicing trades, rather than using its own Estates Department. This would eventually again mean providing sites for workshops, and also either letting its own houses to people who are not its employees, or encouraging local councils to build houses in forest villages. Ultimately independent private building should be allowed.

Another problem in a small new community, to which reference has already been made, is the matter of amenities and amusements, such as the ' pub ' and the cinema. I do not propose to defend the ' pub ' as an institution, but would only point out that it has been argued that the workmen's social clubs which have been established have not the same social value as ' pubs,' since they tend to discourage women and casual visitors, and do not provide accommodation. At the same time it is almost impossible to establish a ' pub ' once a club has been started. I am told that a recent attempt by the Commission to get a ' pub ' going in one place has been defeated by local vested interests. This may be a good thing ; but it is certainly a factor that may influence the moving away of some of the villagers.

Regarding the cinema, it must be appreciated that many of the new forest villagers, coming from towns, are far more used to and dependent on this form of amusement than country folk generally. There are usually arrangements for a weekly cinema show, but it is complained that, for lack of crowds, the takings are so small that only third-rate films can be shown. These do not prove good enough to attract and hold newcomers, who have been used to seeing much better films, so they do not draw as many to see them as can pay the exhibitors a reasonable return even for cheaply rented films. There is grave danger therefore that even the existing arrangements may collapse. Possibly the situation could be remedied by the formation of film societies in the villages, affiliated to the Federation of Film Societies. The Federation puts its member societies in touch with the British Film Institution, through whom good films can be rented at very reasonable rates. This would, however, mean someone to take the initiative, to organise the society, whose members would have to pay a subscription, and to arrange the supply and showing of the films. The society would also need to have its own projector and screen ; these, I suggest, might be provided in the first instance by the Forestry Commission as part of the amenities provided by it for the village.

The higher cost of living than in towns has already been referred to, and this is pointed out to potential villagers before they are accepted. But the men expect to be on piece-work for most of the time and expect to be able to earn at least 25 per cent. above the basic minimum wage. In good weather, this is not difficult, but in bad weather the minimum wage is all that can be earned. Consequently, people who had probably been more used elsewhere to regular overtime extra pay, and who had reckoned on receiving the extra in forestry work, find they cannot manage without it, so leave.

Minor irritations that help to make people readier to move away again are at times due to the lack of flexibility and imagination over the little things of life, which really matter so much to ordinary people, that is apt to dog a big organisation controlled from a distance. A common criticism of life in a forest village is that it is like being in army married quarters ; the Commission's administration is unusually centralised, and its discipline unusually militaristic. It is sometimes forgotten that some Commission employees have a wide experience of life in other industries and conditions ; they have deliberately chosen forestry as a way of life, weighing up the low wages against the surroundings. People making such decisions are probably exceptionally mature individuals, to whom anything in the nature of either a paternalistic or a militaristic attitude is likely to be irritating. There must be scope for the expression of individuality, with as little interference by the Commission as possible in the lives of its employees.

One of the features of modern large industries, both nationalised and non-nationalised, is that all relationships have become depersonalised. The worker does not know his ' boss.' By personnel management and social workers within the industry, personal relationships are catered for by specialists in a scientific manner. Large-scale Government forestry suffers from the same depersonalisation, but unlike other industries it has no personnel management or social workers. It cannot, however, be compared with the more concentrated industries in this respect, and any special personnel staff would find it very difficult to keep sufficiently in touch with the scattered forest labour.

The Forestry Commission is greatly concerned about its workers ; it is reported that at the opening of a village hall a Director of Forestry stressed that the Commission was more concerned with people than with trees. But the officers of the Commission are primarily foresters and are specialists neither in the science and art of personnel management, nor in community problems. At a Rural Life Conference in June 1954, organised by the National Council of Social Service, and attended by Rural Community and Social Service Officers from all over Britain, a suggestion was made that the Commission should appoint a research officer on social relations, so little did they know of personnel management, of community problems, and of rural social organisation ; they had research officers on all aspects of their work except this vital one. The appointment of an expert on these matters might well be worth while.

For immediate problems and under present organisation, I suggest that as much responsibility as possible be left to the local District Forest Officer and his foresters. This might mean a number of mistakes and perhaps find some unable to manage much responsibility, but in the long run it would probably be worth it ; it would help to smooth out many little rubs and avoid the feeling of frustration that often accompanies the delays caused by overcentralisation ; and it would also help in the development of character, letting men feel more that they were living and thinking, not merely obeying orders.

I have referred to the forest villages as being like miniature suburban estates transplanted into the forest. In suburbia every man is an ' island.' A man lives in a community ; he only lodges in an estate. The problem before the Forestry Commission is to transform these estates into real village communities. I believe that ultimately the Commission could best discharge its responsibility in this respect by paradoxically abandoning as much responsibility as possible. By this I do not mean that the communities should be abandoned to their fate, but that they should be integrated into the normal pattern of rural life, complex though that is, with the parish council, the rural district council, the county council, various Government departments, the rural community council, the Playing Fields Association, the welfare services, the county voluntary organisations, and so on, all playing their part. This would mean, for instance, that complaints, if any, would go to the parish council or other appropriate organisation, and not to the Forestry Commission. It would mean a great deal of unselfishness on the part of the Commission, since it would often mean giving special assistance to the forest village without retaining control over the way in which the assistance was used, and without taking the credit for it. It would mean fostering independence, as distinct from a policy of paternalism. But the result would be that the community would come to think of itself, not as a forestry unit, but as an ordinary village, being both part of and with an interest in the wider rural community.

GENETICS AND PLANT BREEDING

SECTION K (Botany) and Section M (Agriculture) devoted the morning of Monday, September 5, at Bristol, to a joint discussion of genetics and plant breeding. Dr. D. Lewis, F.R.S., of the John Innes Horticultural Institution, discussed the part genetics has played and may play in the improvement of plants for modern methods of cultivation and processing. Dr. A. J. Bateman, British Empire Cancer Campaign Fellow, in a contribution entitled 'The control of variability' dealt with methods for controlling the release of variability during a breeding programme and the internal variability of the final product. He was followed by Mr. W. Williams, of the John Innes Horticultural Institution, who treated, in a paper entitled 'Heterosis concepts and the improvement of crop plants,' the concepts and theories of heterosis including an assessment of the value of hybrid forms in the improvement of crops. Dr. R. L. Knight, O.B.E., of the East Malling Research Station, then read a paper on 'The genetical approach to disease resistance in plants' in which he surveyed some of the types of genetically controlled disease and pest resistance and the methods of transferring them to commercial crops. The final contribution to the symposium came from Dr. G. D. H. Bell, of the Plant Breeding Institute, Cambridge. His paper on 'The implication and possibility of organised plant breeding' argues that plant breeding has become such an important means of maintaining and increasing food supplies that it needs an organisation on at least a national basis.

The papers by Dr. Lewis and Dr. Bell are printed in full below.

THE GENETICAL APPROACH TO PLANT BREEDING

By Dr. D. Lewis, F.R.S.

PLANT breeding, as an art or craft, has been practised since the dawn of civilisation, genetics as a science has been studied for little more than fifty years. Can we begin to make practical use of the principles and laws of genetics—and these are perhaps the most exact and fundamental of all biological laws—can we use them in plant breeding?

In trying to place this genetical approach to plant breeding into perspective it may help if we think first of how the much older sciences, mathematics and physics, have been applied to the practical problems of engineering.

Calculations of the power of an engine, or the strength and thermal properties of materials, which are based upon the laws of physics, are of great value to an engineer in designing a new machine. They set the limits to which he must work; but to create a machine such as an aeroplane with all its delicate adjustments and balances requires more. It requires drawings and redrawings, it requires mock-ups in wood, sometimes three generations of them, then trials and adjustments must be made before the final machine is ready. Now just as physicists and mathematicians cannot make planes to order, so geneticists cannot make new plants in the way that some optimists prophesied thirty years ago. But like the physicist they can help in the choice of starting material, in the type of manipulation and in the working limits, i.e. the number of plants which must be grown in each generation to have a reasonable chance of getting the desired result. Put in this light I think we shall see that genetics has and can continue increasingly to play its part in the give and take of a fundamental science and its practical application.

Genetics has, in fact, like other fundamental sciences, opened up a new industry. Admittedly there is only one good example, the colossal hybrid-corn industry in the U.S.A., but possibly in the

not-too-distant future triploid sugar beets in Scandinavia and particularly in Denmark will be another example.

One important step in genetical thought was the clarification of the distinction between genotype and phenotype—between what is inherited and what is apparent in the characters of the parent and offspring. Mendel had a fairly clear picture of the difference, but some of the earlier workers, following the rediscovery of Mendelism, were not too clear about the matter. For plant breeding the distinction is equally important. In the production of hybrid corn, or any other plant for that matter, after forty years of intensive research in maize genetics, suitable parents that will combine to give a desirable hybrid, cannot be chosen on their appearance. This is not surprising because combining ability and general fitness of the hybrid are complex characters under the control of many genes. But even when dealing with a simple Mendelian character the distinction between genotype and phenotype must be made. An obvious example is in a backcrossing programme in which a recessive gene is being introduced into a new genetic background.

In tomatoes a recessive gene *ms* which prevents the anthers from bursting is useful because a female parent for hybrid seed production, which is homozygous for this gene, need not be emasculated. To introduce this recessive gene into the correct background continued backcrossing must be done. The F_1 is *Ms ms*, and the backcrosses will be half *Ms ms* and half *Ms Ms*, which are phenotypically identical but the homozygotes must not be used in the next backcross. Only a progeny test will decide which plant to use as a parent.

This transference of a gene to a new genetic background brings me to another important point. On the somewhat naïve conception, current some years ago in genetical thought, of the genes having only one effect, it was theoretically possible to bandy genes about from plant to plant with no more effect on the organism than the obvious main character, such as the non-pollen shedding in the tomato. But as Professor Mather implied in his Presidential Address the genes do not work in a vacuum: apart from the main obvious effect they have many others due to interactions with the rest of the genotype. This has recently been demonstrated by Dr. Knight in breeding cotton resistant to black-arm, where he found that after continued backcrossing, which theoretically should have resulted in a plant identical with the recurrent parent plus the black-arm resistance, the resultant plant was, in fact, a fraction short of the recurrent parent in several quantitative characters.

Plant breeding cannot go on without selection, whether it be on the phenotype or on the genotype, and until recently it was the sole method of plant improvement. This selection of the female parent alters the natural breeding system slightly, but, today, selection is accompanied by a drastic change in the breeding system, by crossing plants which have previously been isolated and by inbreeding, etc. Not only therefore is it an advantage to know the genetic consequences of the breeding system adopted but it is also necessary to have a knowledge of the natural breeding system of the particular species.

Whether the species is a natural cross-breeder or an inbreeder will determine its genetic architecture and this in turn will determine how the species will react to a particular artificial breeding system. An inbreeder like the garden pea or tomato does not show inbreeding depression, whereas a naturally cross-pollinated plant like maize does. At present little is known about the differences between inbreeders and outbreeders, but it is fairly certain that other important differences exist which would be revealed by the much-needed further work on this important comparison.

A frequent problem in plant breeding is close linkage and pleiotropism. The discovery in *Drosophila* by Mather and Harrison and on other organisms that many of the genes controlling quantitative characters are tightly linked, and that this linkage may only be broken after twenty to thirty generations of breeding and selection is of obvious importance. The discovery in the same experiments of correlated response in which selection for one character frequently affects another unrelated character because of linkage

also has implications for plant breeding. One main occupation of the breeder is to try to break down these unwanted linkages. A desirable gene often carries with it some other undesirable genes at the same time. An example which arose recently in tomatoes was a recessive gene which prevented side-shoots from developing, a character of great economic importance. This gene unfortunately sterilised the flowers. The explanation for this may be either that the two characters, side-shoots and flower fertility, are controlled by two separate but closely linked genes and that both have been lost or inactivated by mutation or that there is one pleiotropic gene expressing itself in flower and side shoot. If it is two closely linked genes then the problem is to try to break up the linkage, if it is one gene the problem is to try to alter its expression by introducing and selecting modifiers which keep the side-shootless effect but modify the flower effect back to normal.

Not all linkages are unwanted and some are very useful. The ten-week stock continually sports double flowers from the singles, which are the only fertile ones. A seedling marker gene which produced pale green seedlings is linked with the gene for doubleness so that plants for bedding and plants for seed production can be segregated in the seed pan, and this has become a great commercial success.

What is badly needed are reliable methods of breaking up unwanted linkages. There are indications that a temporary passage through a tetraploid condition, or heat treatment at meiosis may be effective.

Turning back to the importance of the breeding system, an obvious example occurred quite recently in a problem of breeding the red ornamental garden flax, *Linum grandiflorum*. In a seed merchant's stock a white-flowered mutant appeared, but there were also plants with white flowers which had a red central eye. The seed merchant wanted to breed the pure white flower, and to do this he isolated plants with pure white flowers and saved the seed from them. He was annoyed and astonished to find that these seeds gave many red-coloured plants.

The explanation was perfectly simple. *Linum grandiflorum* is a self-sterile heterostyled species, in which to obtain seed, long- and short-styled plants must be crossed. On careful examination it was found that the pure white flowers were all short styled, and the red-eyed were all long styled—an interesting pleiotropic effect reminiscent of the correlation between Primrose 'Queen' eye and style length in the Chinese primula. He was, therefore, isolating all short-styled flowers and in consequence any seed obtained was derived from pollen coming from the large block of plants some distance from the isolate, and this block contained mainly red plants. The project was abandoned through not realising the breeding system and its correlation in this case with the flower colour.

It is sometimes an advantage in plant breeding to break down permanently a natural breeding system. It is now well known that temperate fruit trees, apples, pears and cherries are self-sterile. To obtain a crop, adequate cross-pollination must occur by planting mixed orchards of different varieties and providing plenty of bees. This has several disadvantages to the grower. It complicates his spraying, manuring, pruning and harvesting programme. But it also probably accounts for poor yields in years when bees are not very active in a cool or wet spring.

The genetics of this self-sterility has been determined in these fruit trees and also in other plants such as tobacco and *Oenothera*, the evening primrose. These plants have the same kind of genetic control of self-sterility down to the last detail. A method has been devised of breaking down this self-sterility system using ionising radiations to induce mutations of the controlling gene and using the style, through which the pollen tubes have to grow, as a sieve to select the rare mutants. But it was done not first with fruit trees; this material was far too difficult technically for the pilot experiments. The best material was found to be an uneconomic species of *Oenothera*, from New Mexico. The method was worked out in detail, the meiotic stage to irradiate, the types of mutations obtained, etc.

The method was then applied to fruit trees with the success expected from the pilot experiment. In fact it was possible

to predict the results down to the last detail. But this example of the exact application of detailed genetical knowledge from one species to another only holds where we are dealing with similar genetic systems. For example cabbages and cacao trees have an entirely different genetic control of self-sterility and we can predict with some certainty that the method of inducing and selecting self-fertile mutants in these plants would not succeed.

Perhaps a thorough understanding of genetic principles is required in no other breeding problem as much as it is in the breeding for resistance to pests and diseases. And not only must we know the genetics of the host plant but also of the parasite. The numerous physiologic races in fungi are now well known and I shall not go into the genetics of this situation, for I wish to use the bare facts obtained from the interaction between host and parasite to illustrate my last point.

Can genetic knowledge help the breeder to decide what characters he should try to improve?

Let us look at the data on fungal diseases of plants.

In most examples, rust in wheat, smut in flax, leaf mould in tomato, wart and blight of potato, the fungus has produced genetical strains which are able to attack a host plant that had hitherto been resistant.

A similar survey of resistance or immunity in plants to insect attack shows a different situation. Insects rarely produce a genetic strain which is able to feed on a resistant host plant. *Phyloxera* resistant vines and woolly-aphis-resistant apples are still fully resistant after one hundred years.

Now let us consider another aspect of insects and fungi, i.e. their behaviour towards a chemical, a fungicide or insecticide. I know of no fungus which has become resistant to a fungicide by producing resistant genetic strains. Bordeaux mixture is still as effective as it was eighty years ago. Dr. Pontecorvo tells me that he has tried to produce resistant strains of Aspergillus to the metallic ions used in fungicides without success. I and Dr.

	Fungi	Insects
Races able to attack 'resistant' hosts	Rusts 18 species Smuts 8 species Powdery Mildews 8 species Others 17 species	
Races able to resist chemicals	Neurospora—Sulphanilamide	Citrus Red Scale — HCN Citrus Black Scale — HCN Citrus San José Scale — Lime Sulphur Codlin Moth — Arsenic Grain Weevil — Pyrethrin House-fly — DDT, Dieldrine Drosophila — HCN, DDT, Parathion, Benzene HV, Chlordane, Nicotine

Crowe have tried in the Basidiomycete *Coprinus lagopus* with a similar result. The only case of resistance in a fungus to a chemical known to me is resistance to sulphanilamide in Neurospora, but sulphanilamide is not a recognised fungicide.

With insects precisely the opposite is found. Citrus scale insects produced genetic strains resistant to HCN as early as 1910. Codlin moth resistant to arsenic, house-flies, mosquitoes and *Drosophila* resistant to DDT are now quite common. The fourfold comparison illustrating these points is shown in the Table.

Whatever is the biological explanation for these differences, if one can be found, the moral for plant breeding seems to me as plain as a pikestaff.

Breed plants resistant to insects and use fungicides against fungus diseases.

In this short account I have tried to show that the geneticist chooses the best material for his problem, while the breeder's problem is to make the best of his material. With the right approach breeding and genetics can surely assist one another in the same modest way that other fundamental and applied sciences have done.

The Implication and Possibility of Organised Plant Breeding

By Dr. G. D. H. Bell

I INTEND in this paper to confine my remarks to the breeding of plants of economic importance with particular reference to the crops of the farmer, because I consider that questions of organised breeding are of the greatest significance in such plants, while, of course, there is no doubt of their primary importance to the world in general and to organised society in particular. Further, when invited to speak on this subject, the programme committee had in mind the part played by this branch of research in modern society, and the recognition of the necessity of developing and maintaining the means of improving crop plants if food production is to be expanded so that it can attempt to cope with the ever-increasing demands.

We should, I think, in the first place try to establish plant breeding in its appropriate context before discussing the matter of organisation. The objective of the crop breeder is straightforward—to provide the grower with improved varieties and strains of his crops for their expanded and more efficient production. In the narrower sense, therefore, plant breeding aims directly at service to agriculture, but in fulfilling this objective it is serving also the community at large, though it may benefit certain categories of society more particularly at any one time. However, when one considers food plants, everyone has a direct interest and a common anxiety in the present and foreseeable position of human nutrition being dependent directly and indirectly on the growth of plants.

The problem of feeding the world today —and in the future if no alternative that is practicable is found to take the place of agriculture as we know it—is a matter of immediate interest and concern. The tax on the natural resources of the world exerted by an ever-increasing human population has received much publicity in recent years, and unless there is some world catastrophe which will engulf the human race, there is the prospect of an ever-increasing pressure on agriculture to produce more food, which inevitably means more crop products. This is not only a world problem, but it is a problem for every nation and for communities within nations. Agriculture has passed through many phases in man's history, and man has developed a complex social system and civilisation as a result of the developments in agricultural techniques. Advanced civilisations no longer expend all their energies on food production, but it is still true that everyone depends on agriculture for their sustenance no matter how remote their lives are from the soil. Even so, there is still a large proportion of the world's population engaged in primary food production, and a very significant percentage that spends its life trying to feed itself.

World food production is now recognised as a world problem affecting every individual, and there is a consciousness awake that is not prepared to see part of humanity living on roast beef and others scraping subsistence at starvation level from the soil. We are afraid, not only for our present standards of living, but also for the future and it is for this reason that

international organisations like the Food and Agriculture Organisation and the Organisation for European Economic Co-operation are striving to grapple with agricultural problems by international co-operation and some degree of planning. The complexity of the problems facing the adequate feeding of the world in the complex social environments that have developed, demands international organisation of agriculture unless there is to be a reversal of progress in man's material and cultural life. Quite apart from the humanitarian and altruistic motives behind such organisations, there is the plain recognition of future survival and national well-being at stake. If it is necessary to regard the basic industry of agriculture in this light, it is logically right to consider every means by which production can be raised, and efficiency improved, through research and investigation.

And this, I think, is how we must consider crop improvement through plant breeding. Throughout man's history there has been a steady appreciation of the necessity to domesticate and improve plants for his use. The history of civilisation is intimately bound up with the history of cultivated plants, and all the important world civilisations have grown up round these plants; the bread wheats of Asia Minor, the macaroni wheats of the Mediterranean; the multitudinous kinds of rice of the Far East; maize in the New World; the potato in South America and the ground provisions of the tropics. The spread of civilisation; the colonisation of the uninhabited parts of the world; the settled development of the densely populated areas with their complicated economic structures and highly developed cultures; have depended in a large degree on developing improved cultivated plants that allow a settled life with an intensive agriculture. There are no vast areas awaiting development now, except perhaps by an inordinate spending of capital, and for the most part the problem of increasing food production is to raise the productivity of the land already in cultivation.

Throughout the written history of the world from stone tablets to the present day there are accounts of the isolated attempts and achievements by man to improve plants by breeding. Up to the nineteenth century these improvements were, as far as we know, largely the result of individual effort, or, in the earlier stages not even consciously achieved by the use of any formal knowledge with a basis of fact resulting from experimentation. The effort and the results were, however, adequate for the purpose and the circumstances when standards of living were low for the masses, when disease was rife, when there was plenty of land available and when population pressure had not made itself felt. But even as long ago as the intensive settlement of the North-American continent, of Australia, of South Africa and other areas it was soon realised that the fate and welfare of the communities could not be left to the whims and exertions of the voluntary worker, and plant breeding needed to be organised to meet the new demands. Without the co-operative and organised work of the breeders of wheat alone, it would not have been possible to build up the North-American wheat-growing areas, and not only would that civilisation not have developed as we know it today, but Britain would not have developed the standard of living that it enjoys at present.

Today the position is more urgent, and many countries have well-developed and organised plant-breeding services that are supported wholly or partly by the State. The implications from the point of view of the State are obvious—this is a neeessary service for the community. The ways in which a plant breeding service are implemented vary in different countries, but the principle that the work should be organised and encouraged is inherent in all. There is, in fact, legislation in most countries affecting the improvement of crops and the making available of better seed for the farmer, and in some cases this legislation is exclusive and discriminative against outside intrusion. Such legislation can be undesirable in preventing free interchange of plant-breeder's products, because these should be available for all, but the motive is either protection for the home-bred product or for the grower.

Attempts to approach the matter more liberally are being made, however, by organisations such as F.A.O. and O.E.E.C. The former is engaged, among other things,

in making available world lists of genetic material in such crops as wheat and rice and in seeing that such material is available to all. O.E.E.C. issued a report by its Food and Agriculture Committee a year or so ago after sending a mission to eleven European countries. The mission was under no illusion that further organisation and development of plant breeding were necessary at national and international level, and they adjured governments to consider whether the breeding work on important economic crops in their respective countries was being done at a reasonable level, and whether there were adequate facilities. There is no doubt that the principle of organisation and co-operation at national and international level is recognised, the arguable points are the nature and scope of the organisation and co-operation as they affect the implications and possibilities for the research worker, for progress in breeding, and for agriculture.

There are those who argue that scientific research should not be organised, but these are the fundamentalists who believe that no research work is worthwhile unless it can be said to be free and unfettered. It is not without significance, however, that at the 12th General Assembly this year of the International Union of Biological Sciences the question of the organisation and support of research in biology was debated. It was resolved that the Union should support, among other things, national co-operative solutions of problems that transcend national boundaries, and the organisation of programmes of research which cannot be organised by individual nations.

Surely, in plant breeding the objectives and responsibilities are so great, and the possibilities so far reaching, that we must accept the principle of organisation for the well-being of the community. On the other hand, in doing this we must recognise the implications and the possible limitations. Apart from the responsibilities to the community, there is the implicit further consideration that the work is directed to achieve a purpose and has a definite aim. It has been suggested that organised research work with definite objectives is the only type of research that is suited to the method of support by specific grants—with also such activities as the collection of data, and development work about which there is no argument. The system has been accepted in this country where we have the Research Councils—Agricultural, Medical and the Department of Scientific and Industrial Research. It is, however, commonly recognised that this method of organisation and support is not applicable to pure research of a fundamental nature which is usually associated with Universities. If this position is regarded as the permanent solution, it can be dangerous in that it perpetuates what I consider to be a false assessment—a hard-and-fast cleavage between the outlook, the methods and the problems of pure and applied research. It seems to me that it would be damaging to both facets of research if this mutually exclusive attitude was encouraged.

While accepting the desirability for proper organisation of plant breeding because of the importance of the work, and the responsibilities of those engaged in it to the community, there must be a proper appraisal of the type of work that may be pursued. Plant breeding has its foundations and inspiration in pure science, and its applications in agriculture; it would be fatal to deprive it of its driving force by creating an artificial applied science which really does not exist. Pure and applied science are surely parts of one whole, and although it is commonly regarded that they attract different types of worker with distinct outlooks, it is without doubt right to bring the two together as far as possible.

I know that there are those who think that plant breeding is still an empirical art relying perhaps more on luck and intuition for success—with perhaps practical experience—than on the methods of scientific research. Nothing could be further from the truth, as I hope you may have gathered from the other papers you have heard today. Even if it were the position a hundred years ago, it is quite certain that this attitude to so-called applied research is one of the weaknesses in many spheres of life today, when although there is happily a marked move to bring scientific knowledge and scientific method more and more into the service of practical arts and technology, there is still not the urge that there is in some other

countries, such as the U.S.A. and the U.S.S.R.

Creative thought and imagination must be the basis of all worthwhile research work, and man's inventiveness must be regarded as a great contribution to the advancement of knowledge, to experimentation and to an understanding of life. Surely we don't wish to discourage those who have these gifts from becoming associated with work that is directed to the common good, nor must we create a system that makes the exercise of such gifts impossible by heading deliberately for a type of organised so-called research that is pedestrian plodding, routine time-serving and mechanical accumulation of data. Even the genius must subject himself to some form of mental discipline and the imagination surely must operate within some context. To obtain the best from these human gifts they must be exercised within a framework of knowledge and be subject to an accepted body of scientific fact. I think it is true to assert that the best fundamental work conducted in the freest of atmospheres can usually find a useful outlet simply because all worthwhile advances in knowledge have a logical place in the pattern of life.

My own assessment of the position is, therefore, that we must find a method of welding the means and the opportunities into a workable and harmonious whole. The particular form of organised research in which I find myself has greater possibilities and opportunities today than it ever had, and certainly more than when I started twenty-five years ago. Organisation cannot take the place of human initiative, ability and creative ability: it must provide the opportunities and not dictate. Authority has built up a considerable edifice for plant breeding in this country and the work is being tackled on a national scale with public money. This provides the setting in material things and the possibilities are inspiring when considered in conjunction with the advances in scientific knowledge and techniques, and also with the problems posed by an agriculture which is becoming technically more efficient and is presenting a constant stream of new demands. Indeed, it may be said that the rising standards in agriculture and the changing economic conditions of this country are providing the breeder with ever greater possibilities and fresh problems for solution.

It is the application of more scientific methods and the greater technical complexity of the problems in breeding that has made the adequate and intelligent organisation of plant breeding necessary. It has also made it imperative that we should enlist good scientists—geneticists, cytologists, physiologists, pathologists and biochemists—to do the work as individuals and as members of a team or organisation that must be leading the field in its own fundamental work and applying the most recent knowledge and techniques. Such work cannot really afford to sit back and await the results of research that may be in progress somewhere else, though it must be quick to apply such results when they become available. The logical place to do the relevant fundamental work is where the breeding work is in progress.

I should like to give some brief account of what is implied by organised breeding work in a few of the major crops of this country to illustrate the problems involved and the necessity for developing a comprehensive approach to this type of research. I shall take wheat, barley, potatoes and sugar beet—four crops with which we are working at Cambridge and which represent four basic cash crops for the farmer in this country, and which therefore contribute fundamentally to the economic stability and well-being of agriculture.

The problem in wheat breeding is to produce varieties which combine the highest yield, while still capable of being handled with a combine harvester or a binder, with good grain quality and resistance to the diseases that are always with us—loose smut, yellow rust and mildew. The combination of the best expression of these virtues demands a well devised breeding programme that is capable of exploiting the most up-to-date breeding techniques, genetic knowledge and field experimentation. The breeding programme is most likely to be based on hybridisation, but it may also seek to exploit such techniques as the artificial induction of mutations.

A hybridisation programme depends for its success in the first instance on the correct choice of parental material, and

in the present state of knowledge this is to a large extent a matter of judgment supported by scientific knowledge and experience. Much can be done, however, to reduce the hazards and save precious time by adopting available techniques for testing parental compatibilities for a character like yield in the earliest stages—F_1 and F_2—of a breeding programme; or by the manipulation of environment under controlled climate conditions so as to reduce the length of the plants' life cycle.

But subsequently, given the best material to work on, the efficiency and success of the project are determined by the effectiveness of selection in hybrid populations when the basis of selection includes such complex genetic characters as yield; earliness of maturity; strength of straw; grain quality for milling, bread-making or biscuits; and resistance to more than one disease. Adequate testing on which selection must be based for all these characters obviously involves quite a complicated organisation in terms of facilities, and also trained personnel, in several branches of science—which include, particularly, genetics, physiology, cereal chemistry, pathology and statistics.

It may be seen, therefore, that the more stringent testing that has become necessary in modern wheat breeding is expensive in terms of facilities and apparatus, as well as requiring skills in several sciences which make it necessary to have team work. It has been suggested by a commercial seeds firm in this country that it costs anything between £10,000 and £20,000 to breed a new variety of cereal, and even so there is no sort of guarantee that can be estimated beforehand of how much of this money can be recouped by the breeder, although considerable benefits may be conferred on agriculture.

It is always a matter for discussion how far plant breeders should go in testing for characters that are essentially processors' requirements rather than growers'. Most of such processors' requirements are usually spoken of as quality characters in the plant product. In wheat, of course, there is the outstanding example of grain quality in terms of the miller and the user of flour. It must be accepted that if the farmer is growing a crop that is to be sold on the open market, then he must take serious notice of the requirements of that market which determine not only the price he will get, but possibly whether he will be able to sell at all. Consequently, grain quality questions become just as important as many other plant characters as far as the economics of the crop are concerned. In this country at the moment grain quality is very important to the grower and therefore the breeder cannot neglect it. It is thus essential for wheat breeding either to organise the testing of such characters in its programme of work, or else to seek the co-operation of other research organisations or of the processors themselves.

A similar problem is met with in barley breeding where the quality of the grain for malting and brewing is of prime concern for the grower. As in wheat, there are biological and chemical characters of the grains determining the processing characters, and if such characters are to be used in routine selection work of hybrid populations, there must be considerable integration and co-ordination of the work. This involves fundamental research into the complex characters, which in some cases involves every stage in the processing, as is being done at some of the industrially controlled research centres.

The principle of accepting selection work by the breeder on processing characters has long been in operation for sugar beet, where the chemistry of the root is studied automatically by all breeders. But sugar-beet breeding is now concerned with other problems which are becoming critical for maintaining sugar-beet growing in a flourishing condition. Most important of these problems is a pathological one—the control of Virus Yellows disease by tolerance or resistance in bred strains. This is something that has reared its head during the last fifteen years or so, and has already necessitated co-operative work between the virus experts and the breeders, and is going to involve very close co-ordination within sugar-beet breeding departments. It is becoming impossible to visualise how any progress can be made in improving sugar beet without carefully organised research under teams of breeders not only for dealing with Virus Yellows, but to study the breeding possibilities of new techniques such as artificial autopolyploidy; the use of wild beet (*Beta maritima*)

in hybridisation; the exploitation of hybrid vigour and male sterility, and other matters which are urgently needing attention if there is to be any radical improvement in sugar-beet strains.

The need for a new approach with a wider basis in the fundamental work may be seen to a similar degree in potato breeding. The search for the new potato hybrid that has resistance to Blight and viruses has been going on for a long time with but partial success. As in sugar beet, new blood is needed and it is to be hoped that this will be forthcoming as a result of fundamental work on the wide range of *Solanum* species being worked on by the cytogeneticists. Here is the new hope with a new synthesis of breeding material resulting from the detailed study of the species for useful breeding characters.

This type of organisation is already in operation in wheat breeding for the exploitation of wide crossing and amphidiploidy in the *Triticinae*. Here, interspecific and intergeneric crosses have been made and new fertile allopolyploids created which can be utilised in breeding programmes. The use of chromosome addition and substitution lines in such work involving the two genera *Triticum* and *Secale* is a new and more refined method that is now receiving attention from cytogeneticists interested in, and cooperating with, the wheat-breeding programmes.

These examples, show the desirability, even the necessity, of organised breeding work in all its phases. Advances in other fields of research make it imperative to incorporate new techniques, and we are now becoming involved even in co-operative work with physicists and medical research work on the effects of radiations, mutagenic substances, and radio sensitisers on the controlled production of mutations of the right type in economic plants.

Organisation in the sense that I have been using the term is inevitable, and it undoubtedly increases the possibilities of achieving results if used properly and judiciously.

THE EDUCATED MAN IN 1984[1]

by

DR. J. BRONOWSKI

I HAVE taken my title from the closing sentences of the address by your President. His subject was *The Educated Man in* 1955 (*see Advancement of Science*, Vol. XII, No. 46, pp. 258–66). But that, of course, in spite of its ring of the present day, is a subject of the past : the education of the man of 1955, your President's education and mine, was largely formed twenty or thirty years ago. When we ask what today's education should do, the man we have it in mind to inform and to form is the man of twenty and thirty years hence. And for reasons which will become plain, the year 1984 carries a symbolism which our education ought particularly to keep in mind.

I

Education in schools and universities has many functions. I shall confine myself to two, both of them dominated by the skills which we need in order later to carry on adult life. Education as I shall discuss it is therefore learning to do something quite precise ; and I shall not be discussing today those other general values which the child and the youth must also draw from his life at school and university.

I have said that the part of education which occupies my mind is the learning of something quite precise. Even so, however, there are different things to be learnt —or better, there are different purposes for which we learn things. I want to distinguish between two purposes, which differ one from the other in their specificity.

The young man at night school learns book-keeping in order to keep books. An engineering student learns the calculus in order to become an engineer. A historian learns Medieval Latin in order to read documents. I learnt Italian in order to read papers in mathematics. These are examples of education for a very specific purpose, and since this purpose often helps us to earn our living, I think of this as vocational education.

But I knew a man once (he was a schoolmaster who had just retired from teaching mathematics) who then learnt Italian in order to read Dante. You will see that what he learnt was indeed precise, and the purpose for which he learnt it specific. And yet I cannot feel that this was vocational education. The learner was not fitting himself for a task, as if he had been a literary critic by profession. He was fitting himself to derive from the work of Dante a larger, a deeper sense of the many-sidedness of human life than had reached and stirred him in translation. He was fitting himself, even at the age of sixty-five, not to make a living but to live, and to take not merely his place but his share in human society.

This is the purpose for which we learn English and arithmetic and history at school. For these are subjects which do not stop at a single need, at writing letters and at making out bills. To read and write, to reckon, to remember the French Revolution, these are actions which penetrate all through the branching nexus, which underlie the whole fabric, of our society. Everything in these skills is precise, but it is not specific to one purpose ; instead, it is part of a hundred arts and a thousand livelihoods. You cannot translate from the Russian unless you learn Russian, but you cannot contribute anything at all to English society unless you learn English. This is the purpose of an education in such subjects as English and arithmetic and history, without which no vocation is accessible to you. These subjects inform and hold together the fragments of society, so that they form and in a sense are its culture.

[1] Address delivered to Section L (Education) of the British Association at Bristol on September 7, 1955.

Your Section and others have been discussing the teaching of science as a vocation : *The Training of the Physicist, the Teaching of Chemical Principles.* (*The papers given in these sessions will be published in a future issue of the* Advancement of Science.) This is an important subject, but it is not my subject in this paper. My subject is science as part of culture, and a scientific education as a necessary part of our cultural education.

This is a broad subject and I do not want to gloss over that. I do not want to pretend that it is something else ; for example, that it is the more fashionable complaint that scientists themselves are uncultured. Mr. Calder has been making this complaint in another Section (*see The Fragmentation of Science*, p. 328), and Professor Mott in your own Section has put forward a practical remedy. This self-criticism is very proper within a professional body such as the British Association. Yes, most scientists are uncultured ; and so are most surgeons and administrators and Greek scholars and Boards of Directors and Doctors of Divinity ; so, in short, are most men who are too busy to write letters to *The Times* in their own defence. I want more scientists to be cultured, literate and human : I hope that I have shown that on other occasions. But I am not in the least impressed when I am lectured on the subject by bishops in the correspondence columns of newspapers, or by generals at school prize-days. When the pundits advise scientists to learn something more, they make it too plain that they find it easier to give good advice than to take it themselves.

Our society is indeed divided between the past and the future, and it will not reach a balanced and unified culture until the specialists in one field learn to share their language with those in another. The scientist has much to learn still, in language and thought, from the humane arts. But the scientist also has a share, a growing share, to contribute to culture, and humanism is doomed if it does not learn the living language and the springing thought of science. The bishops and the generals have some learning to do too : an enormous piece of learning if what they and I value is to survive, and society to become one. My subject is science as part of culture, and a scientific education as part of our cultural education, because for lack of these life-giving parts the ancient cultures are dying at the roots.

II

Here I am often stopped by those whose education and tastes are literary, because they find these claims puzzling. They know what culture is : it is Sophocles and Chaucer and Michelangelo and Mozart and the other figures round the base of the Albert Memorial. And they know what culture is not : it is not laundry lists and sleeping-pills and the proved reserves of oil and the Statistical Digest. In short, culture is not a body of facts : but what is science but facts ? How then, they ask, can science be a part of culture, and why should one learn science to become cultured ? There is no scientist in the frieze of the Albert Memorial.

I have corrected this mistaken view of science a number of times, and particularly in my Carnegie Lectures to the Massachusetts Institute of Technology. Therefore I will not stop to dispute it now except to say that it misses the very meaning of science ; for science is not a set of facts but is a way of giving order, and therefore of giving unity and intelligibility, to the facts of nature.

But I do not need to discuss this large question at present, because the history of education shows that, whatever culture itself may be, the means by which we must teach it are always precise : as precise as my old schoolmaster learning Italian. When the Society for Establishment and Support of Sunday Schools was founded in 1785, it opened the path by which its teachers were to take the children into the Bible with the words : ' Be diligent in teaching the children to read well.' About the same time, the great dissenting academies (speaking through Joseph Priestley) held that all education must have for its end the pursuit of truth and the practice of virtue ; and they taught both, as Oxford and Cambridge did not teach them, in a factual curriculum of logic and medicine and modern languages and mathematics and some science. Against this range of subjects, Lord Eldon long defended the culture of the old grammar schools, for example in the

famous case of the Leeds Grammar School in 1805 ; but even that dying culture was built, as Lord Eldon's judgment insisted, on two precise subjects, Latin and Greek. The founding of the University of London on the initiative taken by the poet Thomas Campbell in 1825, the changes at Oxford and Cambridge about the same time, the rise of the Red Brick Universities later in the century—all these are signs of a profound buckling and shifting of culture. But they are not vague signs, and the changes they made are not imponderable. They are precise changes in what was taught.

The fact is that the syllabus of schools and universities is always in movement from the first of the two educational modes which I am examining today to the second : from vocation to culture. No doubt reading was first taught at Dame Schools as a strictly useful skill ; certainly Latin and Greek were first taught at grammar schools for clerical use ; and arithmetic and technical drawing and debating were taught in the Mechanics' Institutes in order to help those who learnt them to make their way in the world. I will remind you that the show of industrial drawings which the Society for the Encouragement of Arts, Manufactures and Commerce held is one of the beginnings of the Royal Academy.

This example makes my point trenchantly. Some subjects in the syllabus remain vocational subjects ; indeed, even their vocational use may shrink in time until, like spherical trigonometry and graphical statics, they shrink out of the syllabus. Other subjects turn out to have a wider range of uses ; men find that, whether they are farmers or mechanics or bank clerks, they cannot do without them ; and above all, that they cannot do without them as members of society, whatever their profession. So in time these subjects cease to be the prerogative and the burden of specialists, and become general needs. English and arithmetic and history and now French have moved in this way, from the special to the universal, from the vocational subject to a place in our culture. This is the sense in which I have defined a cultural subject. And it is this sense, this movement, which is now patent in the growth of science in our society.

III

Science was once the concern of specialists, and now enters into the life of everyone. The switchboard and the motor-car, the treatment of flour and of cigarette paper, the building of a crèche and of an atomic pile, are our daily concerns ; by these we move and act and live. We simply cannot dissociate ourselves from the hot-water system and the airmail and frozen food and the Linotype machine. A nation unskilled in these, a nation where the screwdriver and the fuse-box are still handled with suspicion, is today a backward nation.

And this goes deeper than the mechanics of earning our living. When a society is penetrated, as ours is, by technical skills and engines, the decisions of state cannot be taken out of the context of science. You cannot as a voter advocate a policy on myxomatosis with any responsibility unless you have a general sense both of the ecology and of the economics of rabbits. You cannot ponder the decisions which we have to make on the development of atomic energy without some understanding, among other things, of how human inheritance works ; you have no right to talk about war and peace, and to vote for rearmament or disarmament, without that. And no member of parliament and no minister can make intelligent judgments on that most profound of contemporary issues, the secrecy which surrounds fundamental atomic research, until he is at home in the tradition of science since Giordano Bruno and Galileo.

The fate of a nation may hang on an error of judgment here. Let me give you a slightly mischievous example. In 1945, the British Government published (as a parallel to the American Government's Smyth Report) a White Paper on the wartime development of atomic energy. Among the documents in this White Paper is the directive by which Mr. Winston Churchill, as he then was, set up the project to make an atomic bomb. This directive begins with the words : 'Although personally I am quite content with the existing explosives, . . .'.

This bland phrase is a monument to a non-scientific education. Think what it would have implied in a dictatorship—where, as the example of Germany shows,

the dictator is surrounded by specialist advisers who are yes-men, and who are therefore bigoted and ignorant even in their speciality. In a dictatorship, Mr. Churchill's satisfaction with existing explosives would have been the end, not the beginning, of serious research towards an atomic bomb. The great man says that he personally is content with the existing state of science ; who then would be strong enough to show discontent ? I do not much care for atomic bombs myself, but still less do I care to have them judged in phrases like Mr. Churchill's. In 1941, they might have weighed life and death between this country and Germany ; and what brought down the scales was not the wisdom of statesmen, but the democratic tradition which caused Mr. Churchill to waive his own unwisdom.

This example shows us succinctly what voters and statesmen do not know, and ought to know. I have called Mr. Churchill's astonishing phrase a monument to a non-scientific education. For it could only have been written by a man, an intelligent man, who simply does not understand how big a million is. The difference between atomic explosives and ordinary explosives is the difference between the length of a nuclear bond and a molecular bond ; and this is a factor of more than a million. To suppose somehow that, in multiplying the energy of an explosive by a million, you are doing nothing very different from multiplying it by two, or five, or ten—this is simply not to grasp the scale of the world.

And the public does not grasp it. To say ' ten to the sixth ' to anybody today, however educated, is still to invite the reproof that one is stressing mere numerical detail. The non-scientist lacks such conceptions, and their lack cripples his judgment in the modern world.

Here we reach the nub of what we mean by a culture. Of course we do not want members of parliament to be atomic physicists or experts in virus diseases ; I do not even want them to be mathematicians. Why should they be ? They are not literary critics or historians. Yet, without being specialists, they know the difference between Milton and Kipling, and what sentiments each of these minds stands for. They know that Pitt and Napoleon were contemporaries and that, in the nature of things, the Industrial Revolution came before and not after the American Civil War. But in the field of science, the voters and those whom they elect have absorbed no such implicit knowledge. They have no framework into which to fit new information, no standards to test it by, and no vocabulary with which to handle it. If I were to say with enough solemnity that the stars must be very young because they are made of neurons and enzymes, no statesman would wink at me. Indeed, in Nazi Germany Himmler planned to found an institution to prove that the stars are made of ice.

IV

To make science familiar as a language, we must start in the schools. A beginning, and a good beginning, has already been made in the General Science course in grammar and public schools. Yet this course still leans too far towards vocational detail, and is not bold enough in the belief that the concepts and principles of science are part of our culture. General science suffers of course from two handicaps : it has to be planned as part of the education of the scientist as well as the non-scientist, and it has to be tied to the moderate and rather dull resources of school laboratories. I accept these handicaps, but even so, I want to fix our minds much more firmly on the lively non-scientist. What can I propose for him ?

First, I want to propose less mathematics than he does now, but that of a more practical kind. That is, I want to change the stress from mathematical manipulation to the meaning of the penny rate and the twinning rate. The language of mathematics is still taught as a dead language, nearly all grammar. I want instead to teach more translation, from the everyday facts into mathematics and thence back into the everyday.

As one corollary, I believe that we need to make statistical methods part of the education of everyone in schools and universities : and this for two reasons. One is that only from statistics can the non-scientist learn to use averages and approximations with confidence, to be unafraid of dividing the national debt or the German battle losses by the population,

and to know in his bones the difference between a million and ten. The other is that modern mathematical statistics is a new view of science, which I believe will transform it, and will replace the mechanisms of Newton by the more subtle concepts of modern physics.

There is another way in which I want to see the teaching of mathematics changed. I think we should be less preoccupied with number and quantity, and more with relations of order and arrangement. This vision of the world by shape and structure is I think characteristic of the newer sciences, and the mathematics teacher can help to make it familiar.

I am thus brought to my second group of proposals, which concern physics and chemistry. Here I think that we should make the atomic picture central to the teaching of both subjects much earlier than we do. There is no need to wait until the chemistry student gets to organic compounds, or the physics student to crystal structure. These pictures of the way atoms are assembled can be made real and exciting to the non-scientist, whose visual sense is often much stronger than his gift for handling either concepts or symbols.

And I think the non-scientist can in the same way be inspired by the outlook of statistical mechanics, much more than by doing Boyle's Law with a piece of barometer tubing. This is really the strength of the atomic model for the non-scientist, that it lends itself both to geometrical and to statistical thinking ; and I should like to see it fully used for both.

My third plea is for more biological teaching than we have now. There is a wealth of natural material and natural interest in plants and insects and the animal processes, which somehow we allow to wither in the grammar school. And as in the other things which I have underlined, it has both a geometrical side, for example in plant structure, and a statistical side, for example in animal genetics.

But more than this, I have the sense that biology offers us a path into scientific thinking by way of the pleasures of collecting and of skill of hand. Liking to collect, to observe, to draw, to take apart and to put together—this is how many children and adults of little other education find their way into the arts. And I feel that there is a way through these also into the sciences : a way which is valuable exactly because it makes art and science one, as Leonardo da Vinci and Andreas Vesalius did.

Fourth, I think we need to teach science, even at school, not as a collection but as an evolution of knowledge. I think this important for three reasons. Because it sees science as a historical development, it offers links with history and literature and geography which can give help and a vivid perspective to the non-scientist. Because it presents science as changing, questioning and argumentative, it can teach the methods of rational debate to everyone in the classroom, and this can be a lifelong lesson. But most important, the evolution of science goes to the heart of the scientific method : for it shows at each step how the logical deduction from what seems to lie behind the known facts must be confronted with experience. We make an induction, we put the deductions from it to test, and on the results of the test we base a new induction. This to and fro between the logical and the empirical is the core of the scientific method, which non-scientists never seize because they do not see science as a progress.

To these four general points I will add a fifth. It is that every boy and girl, every undergraduate, should do one small piece of personal scientific research. It need not be a pompous project, with much search among reference books and writing to distinguished strangers. It can be as simple as the pitch of an insect's wing-beat, or the composition of a rock, or growing a crystal. What is needed is that it should take a little time, a little reading and more thinking, and that it should be done alone. I believe that this small practical experience could change the light in which non-scientists see the long and unsung vigils of the solitary research worker.

V

I do not want at the moment to open the practical questions which these proposals raise. For example, if we put what I suggest into the syllabus, then we shall have to take something out. What is it to be ? What can we sacrifice in the rich distillate of human knowledge—and in the ancient and forbidding history of human

error? I have of course thought about this, and I hope at another time to discuss it; but now is not the time. For if I were to discuss now the merits of rival subjects in the syllabus, we should at once lose the sense of the urgency of what I propose.

And it is urgent. Science must become as a subject part of our culture, or we shall fail, not to train scientists, but to preserve our culture. This is the danger which the letters to *The Times* and the prize-day speeches miss. They speak as if we need do no more than give a little grace and dignity to a few uncouth scientists. But the scientists are inheriting, they are conquering the earth, and if you do not speak their uncouth language, then you will sink to the status of the native yokels when the Normans overran England.

I have called my lecture *The Educated Man in* 1984 in order to warn of this danger. It is certain that the educated man in 1984 will speak the language of science. This is not at issue. The issue is something else. Will the educated man in 1984 be a specialist, a scientist or technician with no other interests, who will run his fellowmen by the mean and brutal processes of efficiency of George Orwell's book? Or will he be a statesman, an administrator, a humanist who is at home in the methods of science, but who does not regard them as mere tools to efficiency? The choice between 1984 and an earthly paradise does not depend on the scientists, but on the people for whom they work. And we are all the people for whom science works.

H. G. Wells used to write stories in which tall, elegant engineers administered with perfect justice a society in which other people had nothing to do except to be happy: the Houyhnhnms administering the Yahoos. Wells used to think this a very fine world: but it was only 1984 or Aldous Huxley's *Brave New World.* A world run by specialists for the ignorant is, and will be, a slave world. A man of taste who sneers at machines, a housemaster with his eye on the preponderance of university scholarships in classics, a civil servant who still affects to despise science, is abdicating his share of the future, and walking with open eyes towards slavery. By leaving science to be the vocation of specialists, they are betraying democracy so that it must shrink to what it became in the decline of Athens, when a minority of educated men (who had to be paid to make a quorum) governed 300,000 slaves. There is only one way to head off such disaster, and that is to make the educated man universal in 1984. This is the force of my programme today, to make the language of science part of the education, the cultural education, of the young who will have either to make or to suffer 1984.

MAN AND HIS MACHINES

SECTION L (Education) devoted the afternoon of Friday, September 2, 1955, to a discussion of *Man and his Machines*. Sir Ben Lockspeiser, K.C.B., F.R.S., Secretary of the Department of Scientific and Industrial Research, opened the session with a discussion of new concepts of science and advanced industrial techniques. He was followed by Mr. Harry Ree, Headmaster of Watford Grammar School, who dealt with automatic control in industry and its effects on the schools. The final contribution came from Dr. J. E. Richardson, Principal of the Northampton Polytechnic Institute, who presented a paper on the training of technicians for the automatic age.
The paper by Sir Ben Lockspeiser is printed in full below.

MAN AND HIS MACHINES

by

Sir Ben Lockspeiser, K.C.B., F.R.S.

PEOPLE turn to machines to save themselves trouble and as few want to do more arithmetic than they must, people have always been on the look-out for devices to make arithmetic easier, or, better still, to do their sums for them. The four operations of arithmetic—addition, subtraction, multiplication and division—are fundamental to virtually all our practical activities, and the practice and study of computation is as old as civilisation itself. Arithmetic is always with us, and like most other mental activities it has become more and more complex and correspondingly more laborious. The invention of logarithms by Napier and the compilation of tables by Briggs, mechanised later in the slide rule, marked a decisive advance in computation. Simple mechanical methods based on toothed wheel machines later reinforced the aids for performing the ordinary processes of arithmetic. But all these devices required some act or other of the human operator at every step, and so it seemed it would always be until a hundred years ago a Cambridge mathematician, Charles Babbage, realising that all the steps of a complex computation constitute a logical whole, conceived the idea of a machine, in terms of cog wheels and levers, which, having been started on a course of computation, would complete it without further human intervention. This was a truly revolutionary conception and the principles underlying our automatic electronic digital computers today are those enunciated by Babbage. If he did not succeed in putting his principles into practice it was because the machine tools of his time were incapable of working to the necessary limits. But in any event, cog wheels and levers are clumsy things compared with electronic circuits, and the thermionic valve, from which the science of electronics has sprung, had yet to be born.

The invention of the thermionic valve by Fleming, which made radio, radar and television possible, had already produced a profound and far-reaching effect on the lives and habits of people the world over, but its potentialities are by no means exhausted. In the last few years it has made possible the automatic electronic computer, which can perform in a matter of minutes calculations that would take a trained mathematician months, even when assisted by the conventional desk calculators. Its use is already becoming widespread not only in research, but also in many industries and activities where the burden of technical computations has been absorbing the time of large numbers of human computers in dealing with such varied matters as the pressure distribution over aircraft wings, ballistic problems, traffic studies both in the air and on the ground, and the reduction of data for weather forecasting. These are only a few of the many applications of the electronic computer which are either in practice or in sight. Two outstanding examples of

these general-purpose electronic computers, whose outstanding characteristics are their speed and versatility, originated in the research laboratories of Manchester University and the National Physical Laboratory. They are engineered and manufactured by Messrs. Ferranti and the English Electric Company respectively. Research is still laying its golden eggs.

The most modern machine has been given the label of ' the electronic brain.' Labels stick whether we think the description misleading or not ; but is it altogether misleading ? That depends on how we define ' thinking.' I do not propose to attempt this, but we must distinguish between routine thinking (which involves the memory and judgment according to specific definable criteria) and creative thinking, and if we remember that the machine cannot create anything we shall not go far wrong. No machine can do more than it is instructed to do by its operator, taking advantage of the characteristics embodied in it by its designer. On the other hand, these electronic computers can be given a very reliable memory for example by means of a magnetic drum (its storage capacity can be very large but not approaching in magnitude that of the human memory), and, because predetermined criteria for exercising judgment can be accurately defined and built into them also, the ' electronic brain ' can perform many of the human functions which we commonly regard as brain work, and perform them far more speedily and more reliably.

The applications of these electronic machines in their fully automatic general-purpose form are likely to be of far-reaching consequence. Because they can receive coded information and store it on a vast scale, and are able to digest and process it in their arithmetic units and disgorge it in a suitable form according to coded instructions, they are capable of carrying out not only all the arithmetical operations of accountancy, but also a great variety of other routine clerical operations. The various steps of the operation require analysis and definition for programming the machine, and all the coded information has to be delivered with great rapidity to take advantage of the high computing speed. What comes out of the machine has in turn to be decoded and presented in a usable form as a printed document, again at a very high speed if the machines are to be used at the highest levels of efficiency. Much remains to be done on these problems, but enough has been accomplished to enable the electronic computer to take over from clerical staff regular office tasks such as invoice calculations, the making up of pay rolls and the compilation of stock and inventory schedules.

Single-purpose electronic machines designed for dealing with a specific task are already in wide use particularly in the United States. The electronic passenger reservation unit recently installed at La Guardia airport, New York, for example, handles all passenger reservations, which formerly kept several hundred clerks busy. A large U.S. firm uses an electronic machine designed to deal with its mail-order business. With its aid ten order clerks can provide accurate up-to-date tallies of 12,000 different items at any time of day and can cope with about 80,000 orders each day. The machine was installed because the large number of clerks previously employed were unable to keep up to date at rush periods, and because they made frequent errors with consequent loss of business.

In this country a striking advance towards the complete electronic office has been made by Messrs. J. Lyons and Company with the introduction of ' Leo,' the first high-speed fully automatic computer to be designed and built for general commercial clerical work. It prepares the pay roll for 10,000 employees, taking into account twenty different items personal to each employee. The job is completed in about four hours, where previously it had been the equivalent of a full-time job for more than thirty clerks. The speed of the machine is matched by its versatility, for it can and is being employed in various other practical operations of the firm in rapidly providing statistics analysed in a form of immediate value to management.

Not the least of the virtues of the fully automatic electronic computer is its capacity to keep track of what is going on inside a large business and print out automatically the trends indicating the need for action, thus conferring a new

power on management control. It is not only that these new general-purpose electronic machines save time, money and labour ; they open up a new field in the calculation of data where the effort would otherwise be so lengthy as to deprive it of practical use and, in any event, so laborious as to be prohibitive. A good deal of intelligent guessing by management will be replaced by exact information and this is bound to bring efficiency to direction and economy to practice.

The capacity of the fully automatic general-purpose electronic computer to make short work of the paper work of a business office can be utilised just as effectively to receive and analyse for action the stream of information that pours in from production shops. The passage of paper from one set of clerks to another, assisted or not by mechanical or electronic aids in their separate tasks, is technologically unnecessary. We may not have quite reached the point where *all* the various tasks demanded of an office can be defined and conceived, as a whole, in terms of machine design, thus enabling the machine to conform automatically to the needs of management ; but that is the way things are going. And these radical changes in the technique of processing data are well suited to exploit the great variety of automatic manufacturing techniques which, in one form or another, have been developed in several industries. The oil, chemical and food manufacturing industries, handling fluids, have naturally found it easier to control automatically the processes of continuous production than have industries dealing with masses of metal of great variety in shape and size, on each unit of which a number of operations have to be performed. The counterpart of piping in the transfer of fluids has to be sought in the form of ' materials-handling ' machines for transferring the work from one set of operations to another. One of the first, if not the first of this kind of transfer machine was developed by Morris Motors as far back as 1923 and the process has been carried much further, chiefly in U.S.A., but also here and on the Continent. Ford and Austin in this country have developed transfer machines in conjunction with automatic machine tools for the automatic production of cylinder blocks at great savings in operating and labour costs, and this technique has been extended here and in U.S.A. and by Renault in France to make a number of other motor-car components such as crankshafts, radiator blocks and oil pumps. Fully automatic foundries are also making their appearance in U.S.A. following on the development of automatic core- and mould-making machines.

A steady increase in the practice of automatic control in manufacturing processes and mechanical handling, both for linking operations and the assembly of components, can be confidently predicted, but the new conception in what is called ' automation ' consists in the integration and control of all the separate automatic production lines, involved in the manufacture of a complex product, by means of some such mechanism as the electronic computer. This is the master control which can be developed to keep track of all that is going on, receiving data from the production lines at all stages, and synchronising by remote control the progress of production of the many components to bring them together in time and place for assembly of the complete product. A motor-car is assembled from about 4,000 processed parts—which gives a measure of the complexity of the operation—and although the motor-car industry has made many bold advances in automatic methods of working, the fully automatic motor-car factory exists, at present, only on paper. Not all manufacturing processes, however, are as involved as this and automatic factories are beginning to make their appearance for the manufacture of simpler products or components, involving successive operations such as casting, forging, heat treatment, machining, screwing, sorting, inspection and packaging. But the main scientific means are in our hands to proceed from the simpler to the more complex, although much technological development will be needed before we can exploit these techniques with confidence. Our declared aim is to double our standard of living in twenty-five years and for its realisation investment in plant for automatic operations is inevitable if we are to get the necessary output with only a million or so

additional people. A corresponding investment in power is a parallel consideration outside the scope of this paper.

An effort of this order will bring many problems, social, economic and educational, in its train. Clerical workers in business offices and manufacturing industry account for about 10 per cent of the working population and we may anticipate a gradual but substantial reduction in this proportion, particularly in large businesses and industrial concerns. In the manufacturing industries there will be less and less room for the unskilled person and in place of machine minders on the shop floor we shall require people who can take the pulse of the machines and tend them. The demand will grow for well-qualified design engineers, skilled maintenance engineers and production engineers trained to take advantage of automatic working. We shall need research scientists, technologists and technicians in greater numbers than we consider necessary even today. Lastly, the march into the future will make heavy demands on management and the art of management will require a strong infusion of technological experience.

The fruits of fully automatic production engineering will only be gathered by a population substantially upgraded in skill and intellect, and the degree to which people are both willing and capable of responding to an advance of this character will set a limit on the pace and spread of the new methods of working. There are other obvious limiting factors which may perhaps relieve us of an undue anxiety without justifying an easy complacency. We made a magnificent effort in the five years immediately after the war by doubling the number of students graduating in science and mathematics as compared with 1939, but there we have stopped, although we are short of scientists and still shorter of technologists for current needs. The corresponding proportional increase of top-class graduates is no doubt less, but we can do with all the trained people we can get. An army needs more than generals. It requires good staff officers and experienced commanders. Likewise with the industrial army, the size and quality of which will depend on our schools, technical colleges, technological institutes and universities. All our aspirations, however, will come to naught unless we can attract a sufficient number of good quality teachers of science and mathematics to our schools. The educational problem of anticipating and dealing with the automatic methods of the future begins in our schools and unless solved will end there.

We all subscribe, on paper, to a liberal and balanced education, but this is an age of specialisation which has been forced upon us by the growth of knowledge and we gain nothing by lamenting it. We cannot turn our backs on specialisation for without it we should be unable to take part in the rapid technological changes of this century and be unable to earn a living. Nevertheless, the society of the future will need a greater proportion of people capable of imaginative and creative thinking which machines cannot give. 'Mankind has struck its tents and is on the march,' said General Smuts, and it is our business to fit ourselves to march with the times.

RECENT PROGRESS IN BRITISH AIR TRANSPORT[1]

by

PETER G. MASEFIELD

AIR TRANSPORT, throughout the world, has today—thirty-six years after its start—become a solid, profitable, business administering to a public need and becoming year by year a more essential element in national life. At the same time, air transport is continuing to expand at a steady rate of around 12 to 15 per cent. per annum and is progressing, technologically, more swiftly than at any time in the past.

These facts present, to both manufacturers and users, problems of a greater complexity than have had to be faced in the general run of industry before. On the other hand, this restless development and the nature of the issues involved—technical, administrative, commercial—account for the remarkable fascination of this form of transport to both those engaged in it and those looking in from the outside.

The technological problems which face air transport's development today fall, essentially, into four major groups :

1. *Aircraft*—including power-plant development.
2. *Navigational aids*—including approach and landing aids.
3. *Ground handling* methods and equipment, and
4. *Airport layout* and construction.

Of these, the first two—the aircraft, their engines, and the means by which they are flown and navigated in all weathers—are those which have the major influence on future trends ; although the second two—the provision and use of ground facilities—are vital to the safe, economic, punctual and efficient operation of air transport services. Nor can one neglect, in any survey of the wider field, the need to provide improved means of transport between the airport and the city centre than any which exist today—with the overhead, aerodynamic, monorail, running on pneumatic tyres at better than 180 m.p.h., a potential of great significance.

First, however, as a background to the problems of the present and of those to come, let us examine briefly the status of air transport in the modern world.

AIR TRANSPORT—1955

In the present year, 1955, the 200 major international and domestic airlines, employing directly some 260,000 persons, are doing business worth some £1,100 million in revenue during the year, earned from the carriage of about 60 million passengers for some 35,000 million passenger miles. In addition the airlines will operate this year some 1,000 million ton miles of cargo and mail. This effort is being achieved with a fleet of about 3,700 aircraft flying about 1,300 million aircraft miles in 1955.

Out of the world total of approximately 4,200 million load ton miles of traffic, the British element amounts to about 7 per cent.—that of the United States to about 60 per cent., thanks to a vast domestic market.

The two British national airlines, B.E.A. and B.O.A.C., together are earning about £60 million of revenue in 1955 and are likely to return net profits for the year amounting to around £2 million, after paying all finance charges, including interest on capital. Both these two airlines have today climbed out of the period of deficit which followed the War and are operating at genuine profits without subsidy. They are returning operating costs and a level of productivity which compare

[1] Address delivered to Section G (Engineering) of the British Association at Bristol on September 6, 1955.

well with any similar services elsewhere in the world.

The life-blood, and also the ' tools of the trade ' of the air transport industry, are the aircraft with which the airlines operate. In this direction the British Airways Corporations have had a singularly difficult time since the War. Even now, B.O.A.C. has not—until the emergence of the long-range Britannia—a British aeroplane capable of flying commercially on the major prestige route of the world—the North Atlantic. The Comet tragedy set back British jet development by at least five years and may prove to have robbed Great Britain of the premier place in civil jet development. Fortunately, in the medium-range field, the Vickers Viscount, operated by B.E.A., has proved to be unique, reliable, popular and profitable in its class, and is the first British-built commercial aeroplane ever to be sold to a domestic air carrier in the U.S.A.

Aircraft refinements, and especially engine development, have been responsible for the economic and operational advances which have been made in air transport over the past three decades. In speed we have accelerated from the 85-m.p.h. Argosy biplane of 1926 to the 320-m.p.h. Viscount of today. In range we have extended from the 500-mile effective sector distance of the Calcutta flying-boat of 1929 to the 4,000-mile effective distance of the Britannia.

In payload we have progressed from the fourteen passengers of the DC-2 of 1932 to the ninety-five passengers of the latest DC-7.

All this has meant a substantial reduction in operating costs, allied with a vastly increased radius of action. For instance, in a comparable category, the Viscount of today can carry forty-seven passengers between London and Zurich in 125 minutes at a direct operating cost of 49*s.* for each passenger seat. Twenty-three years ago, the H.P.42 carried thirty passengers over the same distance in 310 minutes at a direct operating cost of about 109*s.* for each passenger seat.

The modern aeroplane is thus 150 per cent. faster at 55 per cent. less cost—an achievement largely gained by better aerodynamic and structural design and more efficient use of the energy in the fuel as a result of greatly improved power-plants.

Cost and Revenue

At this point we may usefully examine, rather more closely, the typical breakdown of costs in air transport operation. Representative short-haul figures—in actual fact those for B.E.A. in 1955—are as follows :

	Percentage
Pay of staff	42·2
Fuel and oil	13·5
Aircraft maintenance	8·8
Commission payable on sales	6·9
Amortisation of equipment	6·8
Accommodation	3·7
Interest on capital	3·5
Landing fees	3·4
Passenger meals	2·8
Advertising and publicity	2·2
All other costs	6·2

From this we can see that, in the air transport business—as in other industries—staff pay and allowances is substantially the largest item, and tending to go up. After that, fuel and oil is the next most costly figure, and, as a group, the cost of buying, maintaining and operating the transport vehicle—in this instance the aeroplane—is the largest single component in the air transport business. Indeed ' vehicle costs ' amount to about 55 per cent. of the total. This fact emphasises the importance of the most advanced technical thinking being applied to this vital element of the industry's affairs. The more advanced vehicles available today also account, to a large measure, for the fact that air transport, as a whole, has moved from losses to profits while reducing fares.

When we look at the revenue side, we see that (also for B.E.A.) by far the largest item is passenger receipts. The current breakdown is as follows :

Item	*Revenue Account*	*Percentage of total*	*Revenue rate per load ton mile*
	£		
Passengers	15,782,000	83·2	62·9*d.*
Mail	1,392,100	7·4	102·3*d.*
Freight	1,127,900	6·0	43·2*d.*
Commission receivable	455,900	2·4	—
Charter—Sundry revenue	187,100	1·0	—
	18,945,000	100·0	62·9*d.*

The revenue rates show that mail is the most lucrative of all classes of traffic, but, because the volume of mail carried is relatively small, mail revenue—though an important source of income—provides only 7·4 per cent. of B.E.A.'s total. It is also largely 'one way' in character—the national airline usually is given most of its country's mail—so that the net 'round trip' return is less rewarding than the revenue rate suggests.

Economic Factors

In any transport business there are two basic indices which offer a measure of economic progress. In air transport the first is the cost of each unit of work done—the capacity ton mile, which is the product of the load carried and the distance worked. Second is the ratio of 'break-even' to achieved load factor—the percentage of revenue-earning space actually filled.

During the past five years the cost of each capacity ton mile, and the load factor needed to break even, have been steadily reduced, while, for air transport in general, the load factor achieved has been improved. An ideal figure, incidentally, year in year out over all the seasonal peaks and troughs is somewhere between 65 and 70 per cent., if traffic is not to be turned away.

Part of the improvement in these vital statistics has been a result of the introduction of new and more competitive aircraft—such as the Viscount—and partly from improved efficiency and productivity and additional sales effort on the part of the industry in general.

The breakdown of aircraft costs is, of course, relevant to this developing picture. In fact, the cost of operating a transport aeroplane is related to three basic types of costs.

(1) *The costs incurred on an annual basis*—irrespective of the amount of flying done. These include such costs as :

The provision for obsolescence of aircraft.
Interest paid on capital sunk in aircraft.
Aircraft insurance.
Sales and publicity.
General administration and overheads.

(2) *The costs incurred on an hourly basis*—related directly to the number of hours flown. Including under this heading we have such costs as flying staff, fuel and oil, engineering maintenance, passenger insurance and so forth.

(3) *The costs incurred at each take-off and landing*—related directly to the number of landings made. Two items of cost fall under this class. They are landing fees and handling fees. All other commercial costs can be taken as being grouped more appropriately under the heading of Annual Costs which remain constant within a stated budgeting period.

How these three types of cost add up for the Viscount, in B.E.A. service, averages out as follows :

Annual costs :
£127,000 for each aircraft each year.
Hourly costs :
£88 for each hour flown.
Take-off and landing costs :
£18·5 for each landing made.

Obviously, the greater the number of landings made—that is, the shorter the sector flown—the higher the total costs will be. In fact, we see from this one of the fundamental economic factors in air transport—that : *Cost is related to hours flown and to landings made, whereas revenue is related to miles covered.*

Thus the faster the aeroplane and the fewer the landings, the more revenue miles are flown in a year and hence the more revenue earned. So long as the costs of flying faster are not disproportionally increased, the faster aeroplane will be more profitable. That is one of the reasons why the 320-m.p.h. Viscount is significantly more economic than, say, the 260-m.p.h. Convair of approximately the same size.

Specific operating costs also vary fundamentally with sector distance and with aircraft type. Indeed, for each type of aeroplane there is a most economic sector distance. In practice this works out at the maximum distance over which the full payload can be carried. For distances greater than this specific figure, weight of payload has to be replaced by additional weight of fuel. Hence the revenue-earning capacity of the aeroplane begins to fall off.

For distances short of the maximum on which the full payload can be carried, specific costs are higher because of the effect of reduced block speed and the incidence of landing costs.

There are in fact five major economic parameters applicable to the operations of any aeroplane. They are :

(i) *The payload-range* characteristics.
(ii) *The block speeds* achieved at varying sector distances.
(iii) *The utilisation* achieved.
(iv) *The variation* in the relationship between total costs and direct operating costs at different sector distances
(v) *The revenue rate.*

Only by analysis of all these parameters together can an accurate assessment be gained of the economics of a particular type of aeroplane and of a specific route network.

Study of these parameters shows clearly that the most fundamental influence on the cost and revenue structure of any airline is the length of haul. Indeed, under present conditions of scheduled airline service, current fixed-wing aircraft can be operated profitably only on sector distances longer than about 180 miles. The block speeds over short sectors must be comparatively low, because of the high proportion of time taken up in taxying, cockpit checks, take-off, climb, descent, circuit, approach, landing and taxying in. On short sectors the incidence of take-off and landing costs is high and maintenance costs are liable to be increased because of the large number of full-power take-offs and the heavier wear and tear on wheels and brakes.

In the present state of the art, the lowest operating costs are, in fact, achieved by aircraft flying sector distances of about 1,500 miles. At these distances, however, the revenue rates are relatively low—and the greatest profits are being made over distances of about 1,200 miles. The development of the science of aeronautics will certainly increase these ' minimum cost ' and ' maximum profitability ' distances—while, we may hope, reducing also the shortest distances over which economic operations are possible.

Let us now turn from the general position to a more specific examination of the characteristics of three representative types of modern transport aircraft, each designed for a particular sphere of operations —the short-haul turbo-prop (such as the Viscount), the long-haul turbo-prop (such as the Britannia), and the small helicopter of today.

The Modern Turbo-prop Aeroplane

The Vickers Viscount—the world's first propeller-turbine airliner—went into regular commercial services with B.E.A. on April 19, 1953. In the 2¼ years since then B.E.A.'s Viscounts have flown some 12½ million aircraft miles, carried some 630,000 passengers, earned approximately £12,000,000 of revenue and have made a profit of £1,200,000. At the same time, orders for more than 200 Viscounts have been secured from airlines all over the world.

The Viscount is essentially a short- and medium-range aeroplane which achieves its most economic performance at a distance of around 1,000 miles. Its outstanding feature is its type of power-plant—four 1,580 e.h.p. Rolls-Royce Dart propeller-turbine engines running on kerosine.

These turbo-prop engines have four important qualities. They are basically simple—no carburettors, no magnetos, no plugs, no reciprocating parts. They are very light ; less than half the weight of a piston engine of similar power. They originate very little vibration. And although they have at present a fairly high rate of fuel consumption, they run on ordinary household kerosine, or paraffin, which is both cheaper and less volatile than high-octane gasoline and has a higher calorific value.

Thus the turbo-prop engine is popular with both passengers and operators—with passengers because of the lack of vibration, with operators because of its simplicity and good economic qualities.

Operations with the Viscount V.701A in B.E.A. service have shown that it has the characteristics shown in the table.

These figures are still improving and set a standard for modern short- and medium-haul air transport operation.

Great Britain certainly leads the world today in turbo-prop engines. And the great success of the Viscount with these engines, in its medium-range sphere of

	Sector Distance		
	At 200 miles	At 600 miles	At 1,000 miles
Maximum payload	11,808 lb.	11,808 lb.	11,450 lb.
Block speed	150 m.p.h.	245 m.p.h.	270 m.p.h.
Time for distance	1·33 hrs.	2·45 hrs.	3·70 hrs.
Cost per aircraft mile	18·6*s.*	10·5*s.*	8·86*s.*
Cost per seat mile	4·75*d.*	2·69*d.*	2·26*d.*
Number of passengers required to break even on total costs	28·4	18·3	16·6
Total revenue per annum earned by each aircraft at 65 per cent. load factor	£285,000	£464,000	£516,000
Total cost per annum incurred by each aircraft	£265,000	£276,000	£280,000
Net profitability per annum by each aircraft	£20,000	£188,000	£236,000

operations, is evidence of this technical lead.

In the longer-range types, the turbo-prop also gives promise of outstanding possibilities. The Bristol Britannia is designed as a long-range aeroplane for Commonwealth and North Atlantic services. Over short ranges its economics are, naturally, not so good as the Viscount. But it is the most formidable long-range airliner which has yet flown because it combines a relatively high speed with large payload and good economics in a spacious and quiet fuselage.

The most economic sector distance for the longer-range version of the Britannia is some 3,750 statute miles. Over this distance it can achieve a minimum operating cost of tenpence a ton mile—which compares with the Viscount's minimum of a shilling a ton mile achieved at 1,100 miles. At the 1,100-mile distance, however, the Viscount has a lower specific cost than the Britannia.

This brings out the fundamental point that the large, long-range, modern aeroplane will inevitably achieve a lower minimum specific operating cost at its best range than will the smaller, short-range aircraft of equal sophistication at its best range. Which is just as well because of the multiplying factor of distance on fares.

The Helicopter

At the other end of the scale on very short ranges a quite different situation prevails. The fixed-wing aeroplane has a high cost and shows little time-saving at distances short of about 180 miles. But in this realm the helicopter gives promise of becoming an excellent solution on a journey-time basis, because it can fly directly between city centres. Unfortunately, from the economic viewpoint, at

present there is no more expensive means of progression.

The reason for this is that the helicopter is still small, complex and slow. Its small size means that it cannot carry enough payload to cover the basic elements in cost which vary little with size—crew pay, radio installations, etc. Its complexity and its slowness mean that its maintenance costs are relatively high for each revenue mile flown. For the types of helicopter at present available, over a sector distance of 50 miles a fare of at least 30 pence a mile would have to be charged to meet costs—a figure which could not be charged commercially because practically no traffic would be prepared to pay it.

On the other hand, a helicopter cruising at 120 m.p.h. would be able to offer a significantly faster time than any commercial fixed-wing aeroplane of today, up to distances of about 400 miles between city centres. This is simply because the helicopter is not handicapped by the slow bus journey which exists between most cities and their airports.

Indeed, a fixed-wing aeroplane would have to travel at about 3,400 m.p.h. between airports 200 miles apart if the total journey time of its passengers between city centres were to be no longer than that of the passengers flying directly in a 120-m.p.h. helicopter.

The problems which remain to be solved before the helicopter can become a satisfactory commercial vehicle are :

(1) *Size :* Not fewer than 50 seats, to achieve economy.

(2) *Speed :* Not less than 150 m.p.h., to achieve punctuality in all weathers.

(3) *Reliability :* At least two engines, and ability to maintain height with one out of action.

(4) *Noise :* Not more than 80 decibels at 100 feet at take-off and landing, for city acceptability.

Ten years are likely to pass before these objectives are achieved. The helicopter, even then, will have to be confined to routes where the traffic will support a reasonable frequency with good load factors, in vehicles with not less than fifty passenger seats. That means that the helicopter is likely to become—by 1965—a convenient means of transport, at fairly high fares, between large centres up to 200 miles apart. Beyond this distance the fixed-wing aeroplane will continue to be cheaper and, by then, faster.

In the long-term future, however, we must not ignore the possibilities of vertical take off with fixed-wing aircraft—although for a long time to come, the noise factor will probably rule it out of city centres.

Jet versus Turbo-prop

The big issue in the next few years is not, however, whether the helicopter can be made economic or whether the turbo-prop will entirely supplement the piston engine over short and medium distances. It is the battle which is likely to develop over long ranges between the very large jet aeroplane and the big turbo-prop aeroplane.

The basic elements of this battle appear to be that, whereas the jet will be about 100 m.p.h. faster than the turbo-prop (550 m.p.h. compared with 450 m.p.h.), the turbo-prop can be made some 20 per cent. cheaper for each ton mile operated by aircraft of equal payload and range. And the question is whether there is a place for both the jet and the more economic turbo-prop, or whether the higher speeds of the jet will attract so much of the traffic that the turbo-prop will be pushed out of the business on the long sectors. On the shorter ranges, where the higher speed of the jet cannot be used effectively, the economics of the turbo-prop appear likely to hold the field.

Over long ranges—such as the North Atlantic operation—an extremely interesting position is developing with, on the one hand, the British Bristol Britannia, representative of the long-haul turbo-prop, and, on the other, the Douglas DC-8 and the Boeing 707, representative of the larger jets.

Both these latter aircraft are very big indeed, accommodating 125 or more passengers in their tourist configurations, compared with the maximum of 96 passengers in the biggest version of the Britannia at present being produced. Neither of the American jets is likely to be

available in non-stop North Atlantic form, however, for about six years. First deliveries of the DC-8 in a shorter-range form, for United States domestic operations, are promised for 1959.

The Britannia will, we may hope, be on B.O.A.C. North Atlantic services within the next three years. It will thus have a substantial lead in time, experience and reliability over the big United States jets. The '64 million dollar question' is whether the big turbo-prop and its developments will be able to live in competition with the large jets when they eventually emerge.

A comparison of the relative characteristics of these aircraft outlines this most fundamental technical economic problem of the moment. The figures can be set out as follows :

	Britannia 300 *LR*		*Douglas DC*–8
Engines	Proteus 755 (Turbo-prop)	BE.25 (Turbo-prop)	J.75 (Jet)
Approximate date for North Atlantic service	1958	1962	1962
Maximum tourist passenger seating	96	96	125
Maximum payload for London–New York (lb.)	28,000	28,000	32,400
Cruising speed (m.p.h.)	360	420	550
Maximum gross weight (lb.)	170,000	170,000	257,000
Maximum fuel load (lb.)	68,000	68,000	120,500
Maximum sector distance with full fuel and reserves (miles)	5,100	6,100	4,800
Relative cost per ton mile	100	77	82
Representative journey time London–New York (*v.* headwinds)	12 hrs.	10 hrs.	8 hrs.

From these figures—which at this stage must be approximate—we can see that, whereas the big jet has the advantage in speed, the big turbo-prop is likely to be usefully cheaper to operate.

The Proteus 755 Britannia will be substantially ahead of any contemporary piston-engine aircraft in comfort and economy, with at least equal speed. The developed Britannia with the new Bristol BE.25 engines, sixty of which engines are on order by B.O.A.C., seems likely to show a 60 m.p.h. improvement in speed and a 23 per cent. improvement in economy, compared with the Britannia 300LR with Proteus 755 engines. If the Britannia were given a bigger body its economy could be improved a good deal more, without any significant change in speed.

Against this will emerge the new, large, United States jets—represented, as I have said, by the Douglas DC-8 (125 passengers), the Boeing 707 (130 passengers), and also by a new Convair design of about equal size. They are all appreciably bigger than the Britannia and, being jets, are—as the table shows—likely to be rather more than 100 m.p.h. faster than even the more-advanced Britannia. But even with their increased size of payload they are not likely to get down to the same low cost level as the developed Britannia. Indeed, preliminary estimates, made on the most objective basis, suggest that the 96-passenger BE.25 Britannia will be some 5 per cent. cheaper per ton mile to operate, compared with the 125-passenger DC-8 ; which means that, for equal sizes of payload, the turbo-props would be about 20 per cent. cheaper per seat mile—a significant difference.

So we come back to the fundamental question. Assuming equal size of aircraft, will the turbo-prop be competitive with the jet—the turbo-prop taking three hours longer for the London–New York nonstop journey at a return fare which might be £40 cheaper on tourist fares ?

My belief is that there will be a place for both types of aircraft. The big jet will take the first-class traffic at fares quite substantially higher than the tourist versions of the turbo-prop aircraft. The essential thing is that both types of aircraft should fly non-stop in all normal weathers. And the turbo-prop is likely to achieve a high regularity of non-stop operations on the North Atlantic a good deal sooner than the jet. The struggle between the rival forms of turbine power-plant will be settled in the cold, hard light of airline competition and economics—with passengers' pockets and preference playing a dominant part in determining the technical answer.

So, the battle between the turbo-prop and the jet on the long ranges will develop with increasing intensity during the next decade. By the end of that time we may well be seeing revolutionary new types of aircraft, with, possibly, nuclear forms of propulsion, entering the arena.

So, at the present time, we find air transport operating profitably and expanding steadily—still powered predominately with piston engines and meeting increased traffic demands with still more orders for developed versions of existing four-engine pressurised piston aircraft, such as the Douglas DC-7c and the Lockhead 1649.

The turbo-prop aeroplane is, however, on the way in on a substantial scale, with the Viscount already showing the potentialities of this new power-plant in extensive service. Closely behind it comes the long-range Britannia, the medium-range Viscount-Major, and bigger Vanguard, and, on the other side of the Atlantic, the Lockheed Electra. During the next eight years more than a thousand of these three types of aircraft are likely to be sold in world markets. And, during this time, orders for new piston-powered transport aircraft will begin to fade.

The big jets now seem likely to come in, extensively, first on United States transcontinental services—with the de Havilland Comet 4 making its mark on Commonwealth routes, we may hope, still considerably earlier.

Meanwhile, we may hope also that turbine-powered helicopters will be overcoming some of the present inherent shortcomings of the breed.

Further ahead, two major developments are already looming—supersonic passenger transports and vertical take-off. Both of these technological advances can alter the whole pattern of air transport—and of world trade—as we know it today. When the time comes—as come it will—that the trans Atlantic non-stop 'Hypersonica' pops silently and vertically out of the 'spout' of its underground terminal in the centre of London and alights two hours later in its counterpart in New York, then the world will be shrunk to one-tenth of its present size and the possibilities of trade and economic prosperity immensely increased.

BOTANICAL AND GEOLOGICAL HISTORY OF THE SOMERSET LEVELS[1]

by

DR. H. GODWIN, F.R.S.

THE purpose of this paper is to indicate what has been learned by the methods of Quaternary Research of the history of the Somerset Levels through the period between 6,000 years B.C. and the beginning of the medieval period. The evidence centres upon the valley between the Polden Hills and the Wedmore Ridge, a valley wherein lie the famous Iron Age lake villages of Glastonbury and Meare, and where the cutting of extensive peat bogs gives opportunity to collect an unsuspected wealth of evidence.

The methods we exploit are those of diverse scientific fields, bog-stratigraphy, archaeology, geology, pollen-analysis and radio-carbon assay, but the results from whatever sources must finally accord in one valid scheme if they are to be accepted. Let us consider separately, so far as we may, the evidence yielded from the separate sources.

I. GEOLOGY

The Somerset Levels are clearly a submerged landscape and the bottoms of the drowned valleys extend ninety feet or more beneath present sea-level. Borings indicate that they are filled to approximately the height of present sea-level by a soft blue-grey clay, whose content of foraminifera and diatoms shews it to have formed under brackish-water conditions. Pollen-analyses of thin peat layers in its upper part, both here and on the opposite Welsh coast allow us to refer the end of this submergence to the latter part of (pollen) Zone VI, the termination of the Boreal period, which possibly dates to 6,000 B.C.

Upon the flat waterlogged surface of this clay there developed fresh-water deposits and particularly extensive *Sphagnum* bogs which occupied the valley until rather late in the Romano-British period (possibly the third century A.D.) when a second marine transgression brought clay into the valleys. It formed a tidal belt in the Highbridge region, and both below and above it Roman remains testify to its age. Foraminiferal analyses by Dr. W. A. Macfadyen confirm its estuarine or brackish-water origin. This clay extends far up the valley drained by the Parrett, and likewise that of the Axe. It extends from the Axe valley through the Wedmore Ridge at the Panborough-Bleadney gap and spreads out in a thin layer as far as Godney, thereby providing an area of fertile market-gardening soil in a general stretch of acidic peat-land. It even extends through the Godney ridge a little way southwards towards Glastonbury, and will be found on the recent map of the Soil Survey of England and Wales. The remarkable limitation of the clays of this transgression to a coastal belt in the Wedmore-Polden valley must lie, in my view, in the fact that it was not then served by any great natural estuary comparable with those of the Axe or the Parrett, and, indeed, we have historical evidence that the present River Brue estuary is artificial, whilst the straight course of the river shews it to be artificial in much of its length. The old but post-Roman course of the River Brue seems, as Bulleid suggested to me, to have been along from Glastonbury to join the Axe at the Panborough-Bleadney gap.

These circumstances make it evident that Meare Lake and Glastonbury Lake were, therefore, *not* the homologues of the Fenland meres of East Anglia, which were created by Roman estuarine silt blocking

[1] Paper read before Section K (Botany) on September 2, 1955, at the Bristol Meeting of the British Association.

up the valleys from the seaward end. In fact pollen-analyses through the Iron Age village at Glastonbury shew that lake deposits accumulated there right through from the end of Zone VI (when clay deposition ceased) up to the Iron Age itself.

Finally in our time sequence, all over the bed of the Meare Lake there was laid down a further spread of clay, but the shells, ostracods and other faunal remains clearly shew that this was of fresh-water origin. Moreover, its thickness varies in relation to the artificial channel of the Brue, and it can be shewn near Godney to overlie (with intervening organic mud) the margin of the Roman clay at that point. It is a river-borne flood clay, a consequence of general disforestation in the upper reaches of the valley, and is probably of medieval age. It covers up raised-bogs between the Glastonbury and Meare Lakes.

II. Bog Stratigraphy

After the salt-marsh, reed-swamp and fen which in turn grew above the surface of the late-Boreal clay, the greater part of the Wedmore-Polden valley was occupied by the growth of large raised bogs such as now cover so large a part of the Central Irish Plain. They were gently domed in shape and dominated by communities of *Sphagnum*, *Calluna* and *Etriophorum*. Being chiefly dependent upon precipation for continued growth (that is to say, ombrogenous) they were also sensitive to climatic changes of dryness and increased rainfall. Up to the later part of the Bronze Age the peat appears to shew by its high humification, dark colour and abundance of heather and cotton-grass, that it formed under dry conditions, but this stage was apparently concluded by a pronounced flooding episode, sometimes recorded by layers of aquatic *Sphagna* or layers of *Scheuchzeria palustris*, but in others by layers of *Cladium mariscus-Hypnum* peat. The latter demonstrate inundation by calcareous water derived from the Mendip and Polden Hills.

This major flooding-surface is an important guide line in the history of the levels, the more so since its dating is made secure by pollen-analysis as well as by the discovery of artefacts in clear relation to it.

III. Archaeology

Among the many discoveries made by peat diggers and relatable to known horizons in the peat-bogs we may note a Neolithic sherd from Meare Heath (from well below the flooding horizon); a late-Middle Bronze Age spear from Westhay, and another from Shapwick Heath (from just below the flooding horizon); an Iron Age bronze fibula from Shapwick Heath (from a minor flooding horizon above the first and major one); numerous late Romano-British artefacts on Shapwick Heath (interred from the bog-surface above both of the flooding horizons). These finds, backed by pollen-analyses at the site of discovery and exhaustive demonstration of the general pattern of bog-stratigraphy in the valley confirm that at the close of the Bronze Age there must have been a general climatic deterioration and widespread inundation. This conclusion is coupled with a remarkable mass of evidence supplied by excavation and record of buried wooden trackways exposed from time to time in the turbaries. Bulleid described the first of these, Clapham and Godwin (1948) have recorded others, and several more excavated by Mr. H. S. L. Dewar and the author have yet to be published. They vary very greatly in construction and in magnitude; they form however a pattern of connection between the Poldens and the low islands of the valley centre, between those islands themselves and between the islands and the Mendip. On the larger timbers of several of these trackways may be discerned blade marks of dimensions and shape typical of Late Bronze Age axes. The most striking feature of these trackways is, however, that they all lie at the same horizon in the bogs, namely at the onset of the first flooding episode. Indeed, the explanation of their construction is evident. The old bog-surfaces were dry and traversable, but the effect of flooding the big valleys was to destroy all but very circuitous hill connections between sites across or in the valleys. This was the stimulus to track building at the given time, and it likewise explains why trackways were neither rotted nor broken by use, for they were submerged before these processes could take effect. Similarly, it explains why so often the tracks make

use of timber from house or village structures: no doubt the inundations made it necessary to evacuate many lowland settlements.

IV. Pollen Analysis

By analysis of samples taken at intervals through the full depth of the peat bogs and lakes of the Levels, and by this means establishing sample by sample the proportions of different pollen and spore types which they contain, it has proved possible to recover a remarkably comprehensive picture of vegetational conditions throughout the several thousands of years we are dealing with.

We thus deduce, firstly, the general forest cover of the upland. This is the vegetation most directly controlled by the regional climate, and its fluctuations and drifts allow one to apply to the Somerset pollen diagrams the general scheme of pollen zonation used for England and Wales as a whole. We thus easily recognise in the peats upon and in the lower brackish-water clay the declining values of pine and the rising values of alder and the mixed-oak forest which mark the end of the Boreal period (i.e. the end of Zone VI). Zone VIIa is characterised by remarkably high and sustained values for the pollen of elm and lime, values which drop sharply at the onset of Zone VIIb. Finally, in Zone VIII we see the spread in low but consistent amount of the pollen of beech and hornbeam.

In the second place the pollen diagrams give us a remarkably good picture of the vegetation growing locally upon the site of sampling. Thus over a great part of the levels the locally produced pollen supplements and enlarges the evidence of macroscopic remains, confirming the general succession from open lake, to reed-swamp, *Cladium* fen, fen woods, and ombrogenous raised bog. Not only so but we find maxima of Chenopodiaceous pollen indicating salt-marsh both at the base of this sequence and at the time of the Romano-British marine transgression. The flooding horizons are clearly indicated also, sometimes by pollen of *Cladium* or *Scheuchzeria*, sometimes by an abundance of *Pediastrum* colonies or of pollen of fen species like *Hydrocotyle vulgaris*.

Thirdly, the pollen analyses have proved valuable in a somewhat unexpected way as yielding evidence of the appearance and extension of plants in the categories of weeds and ruderals. Such include the genera *Artemisia*, *Rumex* and *Urtica* and the species *Plantago lanceolata*, *P. major*, *Centaurea cyanus* and *Pastinaca sativa*. These first appear consistently early in Zone VIIb, where they reflect the early disforestation by Neolithic agriculturists. In the Bronze Age they contribute a larger proportion of the total pollen rain, and again an increased fraction in the Iron Age and the early Medieval period. It has also been shewn (Godwin, 1948) that judged by this evidence, the climatic worsening at the time of the two flooding horizons caused striking decreases in the local agricultural activity.

Conclusion

We must conclude this necessarily brief glimpse of the main lines of evidence by a short synthesis of the assimilated results. The main results are as follows:

(*a*) About 8,000 B.C., the coastline was far out in the Irish Sea and the hills and vales of Somerset were covered with woodland, mostly of birch.

(*b*) About 6,000 B.C., rising sea-level caused all the Somerset valleys to be flooded and filled up with clay to present sea-level. Thus great salt marshes originated at a time when the upland countryside had become dominated by oak, elm and hazel, with alder and lime beginning to expand. Thereafter reed-swamp, fen, fen woods, and raised-bog in turn succeeded to general occupation of the valleys, leaving, however, open water in such places as the Meare and Glastonbury lakes.

(*c*) By about 3,000 B.C., climate had somewhat changed (possibly becoming less warm) and elm and linden then became less frequent in the upland forests, where Neolithic settlers first began to make clearings, and to husband animals and grain crops. In the Bronze Age such clearance continued.

(*d*) In the late Bronze Age, say 1,000 to 500 B.C., there came a great increase of wetness, the vast raised-bogs, hitherto fairly dry and traversable were flooded by calcareous waters, and became covered with *Cladium-Hypnum* sedge fen. This

evoked the widespread construction of wooden causeways crossing the Levels from one island to another and from one hill ridge to the next. It also set back agriculture and was perhaps the factor which caused the beech and hornbeam to begin to play a larger rôle in the upland woods. Ash, maple and holly at this time colonised the forest clearances.

(*e*) During that part of the Early Iron Age when the lake villages were built and occupied agricultural activities were substantial but these decreased with increasing wetness and rising lake-levels.

(*f*) In Romano-British time, possibly about A.D. 250, came a second marine transgression, filling the Axe and Parret valleys with clay, and building a coastal clay belt across the seaward end of the Wedmore-Polden valley, which was also invaded by the clay at its landwards end by an intrusion from the Axe valley through the Panborough and Godney gaps. In late Roman time there were many burials of hoards into the top of the raised bog at Shapwick, and thenceforward apparently the bogs ceased to grow.

(*g*) In medieval and later time there have followed many attempts to drain the Wedmore-Polden valley, Meare Pool has disappeared, the artificial River Brue has been dug and the artificial estuary excavated at Highbridge. By flooding along these artificial streams there has been laid down a deposit of fresh-water clay which now surfaces the site of the former Meare Pool.

The lecture of which this paper is a summary was illustrated by maps and diagrams giving much of the factual evidence referred to. Most of these can be found, together with more detailed descriptions and comments in the short bibliography appended.

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BOTANICAL ASPECTS OF THE TOBACCO INDUSTRY[1]

by

DR. C. F. SHARMAN

THE title may suggest an examination of the tobacco industry by a botanist. As I am not a botanist I propose to examine the position in reverse, in other words to analyse the problems of the manufacturer so as to sort out those which really take us back to investigations on the growing plant.

I shall not be reporting results or solutions to problems so much as indicating fields in which botanical problems exist and the importance of finding an answer to them.

Over the last fifty years a vast amount of experimental work has been carried out on the tobacco plant. Not all of this, of course, has had a practical end in view—fundamental plant genetics account for a part of it and tobacco mosaic virus has become a classical subject for fundamental virus work. However, a great deal of plant breeding and nutrition work has been directed towards higher yields, higher disease resistance and higher market quality, all of which are directly in the farmers' interest. In addition much effort has been expended in studying the combustion products of tobacco in order to be able to specify in physical and chemical terms the meaning of ' smoking quality ', and, of course, to relate this with the constitution of the original tobacco. This correlation between constitution and quality has been achieved only to a very limited extent ; still less can it be said that we have arrived at the stage of being able to breed and grow tobacco for quality. Indeed, it is safe to say that, without a powerful effort in safeguarding quality on the part of manufacturers, present trends in tobacco breeding and culture would often be in a negative direction. Negative, that is to say, from the point of view of quality. It is the purpose of this paper to show where botanical research can cater for the needs of the manufacturer and the consumer.

The Genus Nicotiana is one of the eighty-five members of the Solanaceae. Among familiar plants it is closely related to the potato and tomato, and especially to the petunia. The genus consists of more than sixty species which range in habit from the small creeping *N. acaulis* to the tall (20-foot) tree *N. tomentosa*, and a number of species contain varying proportions of the tobacco alkaloids nicotine, nornicotine and anabasine. The haploid chromosome numbers cover the range from 9–24 and a characteristic of the genus is its great genetic lability. The evolution of the present tobacco plant has interested a number of geneticists and a fascinating account is given in the recent treatise on the genus by Professor T. H. Goodspeed of California. It is interesting to notice that the world distribution of wild plants of the genus has practically no connection with the distribution of tobacco produced commercially. This wild distribution is confined to the Western States of North America and the southern half of South America, the West Indies, the southern half of Australia and a few Pacific islands. All the main production areas of tobacco are outside these limits. Although in the past the term ' tobacco ' has probably been applied to a number of species, today the tobacco of commerce arises from *N. tabacum* only. The only other species of commercial interest is *N. rustica* which is grown in Russia for smoking, under the name ' Makhorka.' It is also grown by some primitive tribesmen for their own consumption, and

[1] Paper read before Section K (Botany) on Tuesday, September 6, 1955, at the Bristol Meeting of the British Association.

elsewhere to some extent for nicotine manufacture. It appears that *N. tabacum* is never found as a truly wild plant, although it occasionally escapes from cultivation and survives for a few generations. It must be looked upon as a highly sophisticated member of the genus which is incapable of surviving without the help of man.

Just as the Genus Nicotiana has proved a happy hunting ground for the plant geneticist, so the species *tabacum* would appear to be a favourable subject for the commercial plant breeder, for its wide range of varieties, its prolific seed production and the ease with which it can be self- and cross-pollinated simplify his task of producing combinations of the characteristics he may desire in the cured leaf. Unfortunately, there are two factors in the case of tobacco which to a great extent neutralise these undeniable advantages. In the first place, in contrast to crops such as sugar beet where the requirement is relatively simple (the maximum number of pounds of sugar per acre), tobacco requirements are highly complex, and in many respects cannot yet be specified in physical terms. Secondly, although a number of plant properties such as yield of dry leaf, resistance to disease, colour, etc., can be determined within a few weeks of harvesting, the ultimate value of the product to the consumer can be assessed only after a period of from one to three years of maturing, followed by the manufacturing process and eventual combustion in the pipe or cigarette. This means that much of the work of the plant breeder must proceed blindly or by intuition since the visible characteristics of the cured leaf are only remotely correlated with the final smoking quality. It is, therefore, hardly surprising that the greatest progress has been made in those properties which can be assessed immediately, notably yield and resistance to disease, and that relatively little attention has been paid to ' quality ' as understood by the manufacturer and consumer. We shall see that apart from the ultimate smoking quality of the product there are also a number of important economic aspects which arise as a special feature of the tobacco trade in the U.K. and which depend upon the plant and the conditions under which it is grown.

The wide range of variation of tobacco in commercial production is illustrated by the 6-inch leaves of Turkish tobacco as compared with the 24-inch leaves of other growths. All these types are annual plants grown under semi-tropical, and often rather arid, conditions usually in light sandy soil with heavy fertiliser applications. The large leaves are sticky and covered with glandular hairs. The particular features which make tobacco of commercial interest are that its leaves can contain from 1 up to about 10 per cent. of the alkaloid nicotine (on a dry basis)—the usual figure is in the neighbourhood of 2 per cent.—and that they are capable of curing to a tough lamina which when shredded will, as we say, ' hold fire.' Anyone who has experimented with coltsfoot, raspberry leaves or any of the other ' herbal ' substitutes for tobacco might well come to the conclusion that tobacco was specially designed for man to smoke.

Although the many botanical varieties are of obvious importance to the farmer who has to maximise yield, disease resistance, curability and visible market quality in order to realise the maximum monetary yield per acre, as soon as the cured leaf enters commerce the significance of variety is largely lost. The main classification is then in terms of the method of curing of which there are four types :

(1) Flue curing yields bright tobaccos which constitute virtually the whole blend of British-type cigarettes and a considerable but varying proportion of British pipe tobaccos. In this method the detached (or ' primed ') leaves are hung on sticks in barns in which the temperature is raised by means of sheet metal flues carrying the heat from external furnaces, or by some modification of this method, and the humidity is roughly controlled by means of ventilation. The curing time is about five days and a barn holds about 1,000 lb. of cured leaf.

(2) Air curing covers cigar tobaccos (which are subsequently fermented) and Burley which enters largely into the U.S. type of ' blended ' cigarette, but is little used in this country. For these types no artificial heat is

applied in the barns and ventilation is unrestricted. The curing time is much longer than with flue curing.

(3) Sun curing is mainly applied to Oriental leaf produced in Greece and Turkey. The whole plant is cut and curing is carried out in the field often on racks.

(4) Fire curing yields dark-coloured leaf used in pipe tobacco only. In most respects it resembles air curing, but small wood fires are kindled on the floor of the barn which impart a smoky flavour to the leaf.

In general the curing process may be considered as an extension of the ripening of the leaf on the plant and in some ways as parallel with the normal senescence and death of a leaf in nature. The descriptive word ' agony ' has been applied to curing by some German writers. At harvest the leaf chlorophyll has already begun to break down and starch has partially been converted to sugar. The first stage of curing carries these processes to completion and in flue curing the biochemical degradation is stopped at this stage by drying the leaf out quickly, thus stabilising the bright colour and the high sugar content. In the other three methods, the degradation proceeds further, the colour changing to brown and the sugars being fermented completely away. At the same time the nitrogenous constituents are entering in the degradation. The process is continued even further with cigar leaf, which is given an intense fermentation in bulk in which the nitrogenous bodies become heavily involved and large amounts of ammonia are given off. The final stage in all methods is to dry the leaf in order to stabilise it in the required condition. Storage of cured tobacco in the dry state over a period of many months before manufacture allows some slight degree of ' maturing ' under the storage conditions in this country, but the changes involved are small and subtle as compared with those occurring during curing.

In any territory for marketing purposes each type is divided into ' grades '—often scores of grades in each type. The grading is on the basis of colour, texture and aroma, all of which are subject to the influence of season, culture, variety, position of leaf on plant, and efficiency of the curing technique.

The history of tobacco production from early times up to the gigantic industry of today is a fascinating story for which I have no time; but I would mention that W. W. Garner gives an excellent and readable account in his book on *The Production of Tobacco*. The total world production of all types is at present about 8,000 million pounds per annum, enough to provide a weekly ration of 1 oz. to every man, woman and child alive today. This must require at least 10 million acres of land and each acre absorbs labour at the rate of approximately 400 man-hours per annum. If we add in a conservative figure of 2,000 million man-hours for manufacture we get a total human effort of about 6,000 million man-hours per annum or the full-time work of 3 million people.

The visiting botanist will have noticed in Bristol the evidence of its importance as a tobacco port and as a centre of tobacco manufacture, but will realise from these figures that only a small fraction of the total world effort is represented here.

The conditions under which the tobacco industries in different countries operate can be so variable as to give rise to virtually different industries. The U.K. is an excellent example since here we have a public demand of a type very different from that in most other areas of the world, virtually no native commercial tobacco production, the highest rate of duty in the world and a system of collection of duty which raises a number of important economic problems in manufacture. If there is one single factor which can be said to dominate the industry in the U.K. today it is that the leaf may enter the country having a value of say 5/– per lb., which after paying duty and being cleared from bond for manufacture has a value of over 60/– per lb. and becomes almost as precious as silver. The creation of such a fictitious value obviously can give rise to all sorts of possibilities, but to the tobacco manufacturer the problem really reduces to one of making the best possible use of his available material or, what comes to very much the same thing, giving the consumer the best value for his money.

Owing to the high money value of this

semi-precious vegetable and its leading position as a state revenue producer it is perhaps inevitable that the legal requirements which the manufacturer has to fulfil should be stringent; from the purely technical point of view they might be considered as archaic and often illogical. They have, however, resulted in one outstanding feature which is characteristic of the British cigarette, namely the strict legal insistence that the filling of cigarettes shall consist of tobacco only. In this connection I should perhaps try to explode what we may call the 'great saltpetre fallacy.' A sizeable proportion of the smoking public still seems to believe that manufacturers add saltpetre to cigarettes to make them burn, whereas, in fact, such an adulteration would be not only grossly illegal but entirely unnecessary since the property of combustibility is inherent in the cured leaf.

Special Manufacturing Requirements

Since cigarette production accounts for the greater part of the tobacco trade in the U.K. it is useful to consider this case in detail as the special requirements are closely related to botanical factors in the production of the cured leaf. Briefly, the problem of the manufacturer for the British market is to fill a paper tube of an acceptable size with enough tobacco of the most acceptable blend to give the cigarette a satisfactory firmness and burning properties at the minimum cost. His efforts to do this are subject to a number of complicating conditions:

(a) The most desirable constituents of the blend obviously tend to demand a higher price on the market.

(b) Types of tobacco of desirable aroma and burning properties, by reason of high hygroscopicity or otherwise, may react deleteriously upon the firmness of the cigarette.

(c) Leaf which is otherwise highly desirable as a cigarette constituent, may suffer from difficulties in manufacture such as an undue tendency to breakage in the manufacturing process.

It must be clear that whatever improvements in the process the cigarette manufacturer has made and may make in the future, these properties which are of such great importance in the U.K. trade must largely be grown into the original leaf. Hence it is important that the desirable physical properties which represent this quality complex should be related back to the genetic, cultural and climatic conditions under which the leaf is grown.

I have already mentioned one of the difficulties of this type of investigation arising from the remoteness both in time and space of the consumption of the product from the growing of the plant. Another is that consumer preference has to be determined by subjective testing methods which are by their nature imprecise and which at present can be replaced by objective chemical analysis only to a limited extent.

From these considerations it is easy to see that the demands of the consumer based on overall quality may not be consistent with the ideas of the plant physiologist as to what constitutes a sound tobacco plant. The complicated story of nitrogen metabolism of the tobacco plant illustrates well the gulf between these two sets of ideas. With heavy applications of nitrogenous fertilizers and with adequate moisture and micronutrients, magnificent physiological specimens are easily grown even in the normal English summer, but the nicotine and protein contents will be so high as to give an entirely unacceptable smoke. Limitation of soil nitrogen especially in the later stages of growth is necessary to prevent this rank growth, but the finer points of smoking quality are related to many other agronomic factors in a way which is at present largely unknown.

To sum up I have tried to show how the botanist can serve this huge industry, how in the past his efforts have been largely in the interest of the leaf producer and how much scope there is for extension to cover the interests of the manufacturer and the consumer. I believe real progress can only be made if there is a fair balance struck between these often conflicting interests. There are indications that this is now being appreciated.

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THE FRAGMENTATION OF SCIENCE[1]

Address by

RITCHIE CALDER, C.B.E.

PRESIDENT OF THE ASSEMBLY OF CORRESPONDING SOCIETIES

THROUGHOUT the 124 years' existence of the British Association, the tradition has been for Presidents of Sections to deliver their addresses as *ex cathedra* statements, not subject to debate. I am, with due respect for the tradition, departing from it. I propose to shorten this address and provoke discussion in which, I hope, my allotted time will be employed.

I am glad to have, and to provide, this opportunity for consideration of a process which is getting progressively worse—this fragmentation which is corrupting science and bedevilling the public judgment of science. In no Section of the Association is this fission and confusion of science likely to be better understood than in our Assembly of Corresponding Societies. I am not implying that there is an unawareness or lack of concern in the other Sections; indeed, my hope, in departing from presidential precedent, is that members of other Sections will join us in our debate. The Assembly, however, has a special place in the pattern of the British Association. It has been described as 'the common-ground of the amateur and the professional,' but I should qualify that and say that in our societies, and in this Assembly, the professionals *are* amateurs in the O.E.D. sense of '*One who loves, is fond of, or has a taste for anything; one who cultivates anything as a pastime.*' By that definition we are not divided into Gentlemen and Players. In this Assembly we discard the overalls of specialisation for the overall of science. Many of us may derive our livelihoods from science but we owe something to science in return—and that is to see it as a whole and not just as the separate wickets at which we draw our pay-packets. Therefore I say that as lovers of science we must contemplate with misgiving its present state—divided, as it is, within itself, by overspecialisation; divorced, by incompatibility, from the humanities; and estranged, by misunderstanding, and, indeed, by fear, from the lay-public.

2. SCIENTIFIC BABEL

On a previous occasion in this Assembly (*Presentation of Science to the Public*, Brit. Ass., Liverpool 1953), I had the impertinence to suggest that scientists, by and large, were illiterate, inarticulate and irresponsible—illiterate, because literacy implied the capacity to communicate ideas; inarticulate, because they could not convey what they were doing, how they were doing it or why they were doing it; and irresponsible, because they left their discoveries like foundlings on the doorstep of society. Now, as then, I admit that that is unfair to many scientists who are at great pains to be comprehensible, to be explanatory and to recognise their responsibilities. For the rest, I am impenitent. In this paper, I shall aggravate my offence and say that most scientists are becoming intellectual cripples; by using only part of their faculties and allowing the others to languish.

The reply can be that a musician is not expected to explain his music, that he speaks with his instruments; nor the painter to explain his pictures, that he paints from his 'inner self'; nor the poet to explain his poetry, that people, to understand it, must feel as he feels. Artists, living only for their art, are, in my sense, cripples too. But art does not, as science certainly does, have powers of life or death; it does not change the pattern of human life or threaten the livelihoods of the millions. We carry the

[1] Address delivered on September 1, 1955, at the Bristol Meeting of the British Association.

artist as a passenger ; the scientist is at the wheel, and if he has no sense of traffic, just the obsessional preoccupation of his own interests and no idea of the dislocations and upheavals he can cause, then he is ' driving to the public danger.' One can argue, as I myself have done, that the fault is not entirely on the side of science. The preacher who complains that advances in science are outstripping moral responsibilities piously says that he knows nothing of science. The statesman who boasts his ignorance of science nevertheless thinks himself competent to legislate for the atomic bomb. The man in the street, alternating between fear and jeer, blaming the scientists for the new weapon which threatens his home and the new device which threatens his job, does not pretend to know what science is about or ' what makes the scientist tick.' Through the failure of our educational system and the faults of our newspapers, the average person, and even those who are qualified to know better, regard any scientific discovery as a miraculous revelation and every scientist as a genius.

Very few scientists are geniuses. They are just the ' run of the mill ' with certain aptitudes, trained to use those aptitudes in certain ways and to think systematically. Their brains are not custom-built ; their skulls have just the same cubic capacity as other peoples' and their day has the normal twenty-four hours. Because they have only this limited capacity and time, and because they have to devote both, if they are in research, to their speciality to the exclusion of almost everything else, it is manifestly absurd for me to blame them for not being supermen, and at the same time to blame the public for regarding them as such. So in personalising the scientists and criticising them, I know I am being unreasonable, but, you see, for over twenty years I have been dealing with scientists who have names and faces and not with something abstract called ' Science.'

The trouble, twenty years ago, was not that the scientists could not explain. They could but they wouldn't. Today, I should say that they want to, but they can't. The Ivory Tower is no longer inaccessible but it has suffered the fate of the Tower of Babel.

In the words of the Old Testament : ' *And the Lord said . . . " Go to, let us go down, there confound their language, that they may not understand one another's speech.*" '

Please do not misunderstand me ; this is not the grievance of a science editor being frustrated in search of ' copy.' We science-writers know our way around. When we want to get an explanation of something, we eventually can, and do. We are Babelologists, students of the ways and languages of the scientific Babel. I deplore the confusion of tongues for reasons other than my professional ones and it does not gratify me to find that often my function is not only to act as an interpreter between science and the public but between scientists, in the disparate branches, themselves. Over-specialisation and the jargon of over-specialisation have now reached a stage when scientists in the same subject cannot understand each other because the subject has subdivided itself. Scientists working in the same laboratories have confessed to me that they did not know ' what the other fellow was doing.' If you like, that is lack of curiosity, but also it is the preoccupation with one's own job to the exclusion of everything else.

An eminent physicist once reported to me an experience he had at a very select scientific dinner. It was at the time when myxomatosis had not become commonplace—as ' myxo '—in the conversation of the village bar, and our countryside, was still unlittered with dead and dying rabbits. This man-made epidemic was still far away in Australia and uncommon enough to be fit subject for discussion at a scientific dinner. The physicist, to make intelligent conversation, asked his neighbour, a distinguished bacteriologist, what were the clinical characteristics of the disease. ' I really don't know,' said the bacteriologist. ' It is a virus disease. You had better ask a virologist.' The physicist turned to his other neighbour, an entomologist, and asked him about the mosquito—the carrier of the disease. ' I really don't know,' said the entomologist. ' My speciality is so-and-so.'

The physicist quoted this as a ' score ' against the biologists but I pointed out (and quoted cases of) the same sort of thing in his own subject and with malice

aforethought asked him an awkward question on semi-conductors. '*Touche!*' he said, 'I really don't know. Ask me something about the nucleus.' The semi-conductor—very important in practical electronics nowadays—is a phenomenon of the behaviour of the electrons of the atom, but even in the infinitesimal world of the atom you have electron-physicists and nuclear-physicists.

If I had gone to that bacteriologist or entomologist seeking for publication an authoritative explanation, I would have understood the reticence of their advice to try experts closer to the subject. (That happens every day.) My point in quoting the experience of the physicist rather than the innumerable instances from my own experience is because it shows that so great are the inhibitions of the specialists that they cannot risk information or opinions outside their own subject even among their scientific colleagues, or, perhaps, especially among their scientific colleagues. Contrast that with the days of the far-ranging discussions of the Invisible College which preceded the Royal Society, or of the variety of interests of the founder-members of the Royal Society, or the versatility of that extraordinary coterie, the Lunar Society of Birmingham, where they used to discuss poetry, religion, arts, politics, music and science with their minds unbuttoned like their breeches-bands. Or with a club with which I used to dine regularly in the 1930's. There, scientists with names with which we conjure today used to meet and discuss not only their own subjects but every subject, inside and outside science. It is in recess *sine die* because we are all too busy over-specialising.

3. The Object Lesson of the Lunar Society

To point the moral and illustrate what, I feel, we have lost, I should like, briefly, to revert to the Lunar Society. (You may recall an excellent chapter on it by J. A. Skipper, in the Scientific Survey with which Birmingham presented members of the British Association in 1950.) 'The Lunatics,' with method in their madness, used to meet every month on the night of the full moon, because that was the lantern which had to light Erasmus Darwin back to Lichfield and Josiah Wedgwood back to the Potteries. Never more than ten people ever sat down to dinner at the Lunar Society, yet that group, through its members, changed the history of mankind. Its three founders were Matthew Boulton, William Small and Erasmus Darwin. Small was introduced to Boulton by Benjamin Franklin, who became a corresponding member of the Society, but Small belongs to history in his own right. I suggested recently in the United States that he was responsible for Senator Joe MacCarthy, because Small, a Scotsman, had been Professor of Natural Philosophy at Williamsburg. One of his students was Thomas Jefferson, who wrote in his autobiography, 'Small probably fixed the destinies of my life.' He probably did more, because of the peculiar marks of scientific influence imprinted on the Constitution of the United States. As Woodrow Wilson pointed out, that Constitution was based on a theory of political dynamics 'which was a sort of unconscious copy of the Newtonian theory of the universe,' a system of government in which action and reaction are equal and opposite and all bodies are nicely poised by the balance of forces acting on them. The Executive is checked and balanced by the Legislature, and both by the Supreme Court. A Senator can set the President in defiance, *ergo* William Small was responsible for MacCarthy.

Small played midwife to history in another respect. When he retired from Williamsburg to Birmingham he was instrumental in introducing James Watt to Matthew Boulton, to give the Industrial Revolution its steam-power. But the Boulton and Watt engine might not have been perfected if Wilkinson, the cannon-borer, had not been a member of the Lunar Society and, through it, the means of providing the partners with the lathes accurately to bore their cylinders.

Withering, the physician who had discovered digitalis by watching a Shropshire grannie brewing foxglove tea, was an amateur geologist who introduced Jos. Wedgwood, the Prince of Potters, to *witherite* (barium carbonate) and led to the famous *jasper ware*. Wedgwood, and the other members of the Lunar Society doing good by stealth, enabled Joseph

Priestley, the unitarian minister, to carry on his experiments, but the Lunatics' discussion of oxygen (confused as it was by phlogiston) gave Wedgwood the insight into oxidisation, as a step to replacing brown pottery by Wedgwood white china. (Incidentally, Wedgwood was probably the earliest industrialist to employ operational research. As a result of studying the relative costs of the breakages of pottery on the turnpikes he became a promoter of Midland canals.) Keir, a 'Lunatic,' gave the Industrial Revolution its industrial alkalis. Roebuck, a 'Lunatic,' gave it mass-produced sulphuric acid. Watt brought Berthollet to the Society, and the result was the chlorine bleaching of the textiles mass-produced by steam-powered looms. It is fascinating to study the interplay of ideas because those 'Lunatics' had a natural curiosity which turned into handsome profits or—shall we use the new, decontaminated word—productivity.

They were all practical men, specialists in their own way, but they were also Francis Bacon's 'Merchants of Light.' (You recall, in *New Atlantis*—'*But thus you see we maintain a trade not for gold silver or jewels, nor for silks, nor for spices, nor for any other commodity of matter; but only for God's first creature, which was light; to have light, I say, of the growth of all parts of the world. . . .*') No record was ever kept of the proceedings of the Society lest the informality of its free ranging discussions be embarrassed; there were no transactions, no agenda, no resolutions and no programmes of action and no research-projects. They discussed everything. James Watt, the 'philosophical instrument-maker' or, as we would say, laboratory mechanic, would argue music with the Private Astronomer of the King, William Herschel, who had come to Britain as a German bandsman; Erasmus Darwin, physician, poet and philosopher, when he was not propounding creative evolution and anticipating Charles, his grandson, would be telling Boulton how to improve on some new mechanical invention. When Priestley was not discussing chemistry with Wedgwood, he would be supporting Samuel Galton in defence of the American rebels and quoting his latest letter from Franklin. They were not afraid to discuss religion or politics and there are uncanny parallels between then and today. Priestley was a supporter not only of the American but of the French Revolution. He was denounced by Burke; and the French Revolutionaries nominated him a member of the National Convention—the eighteenth-century equivalent, I suppose, of being made a Stalin Prizeman. When the Birmingham mob rioted, shouting 'Church and King,' its violence was directed against The Lunatics. Boulton and Watt barricaded themselves with guns at the Soho Foundry. Priestley's house was burned, and his manuscripts, the work of twenty years, were strewn throughout the countryside. Perhaps it is unwise to remind people of that. I can hear some saying, 'That's what happens when science gets mixed up in politics.'

4. Science and World Politics

That is absurd. Science, today, *is* politics—world politics not party politics. It dominated, whatever the items on the agenda, the discussions of the Big Four at Geneva. I have just been taking part in one of the biggest political conventions in history—except that anything which could be naively construed as 'political' was barred. But does anyone here doubt that the United Nations' Atoms for Peace conference, at Geneva, was influencing the politics of our times. Science cannot divorce itself from politics any more than it can from economics, because it is the integral force of both. And it is absurd for scientists to pretend to be apolitical—I am not now discussing party labels—because they are inextricably involved.

No scientist—I repeat, no scientist—is immune from politics. Could Rutherford ever have foreseen that his pure research into the nucleus would one day bring the Great Powers to Geneva? Or could Clerk Maxwell have foreseen that electromagnetic waves would be the most powerful political propaganda instrument of the Cold War, or, for that matter, of the British and American domestic elections? The biochemist who says 'At least I cannot get involved. I am working on hormones,' presently finds himself 'classified' because his work impinges on biological warfare. I have just been travelling with geologists through the polar islands of Canada. None of them, I am sure,

suspect the politics which they are unleashing—because they have now revealed those hitherto meaningless islands as repositories of what may be one of the world's greatest oil-reserves. In the Middle East, I innocently suggested that I might help to organise an international archaeological expedition to help to find ancient water systems which might still be useful in that thirsty region. My escort eyed me with cold mistrust and said: 'We, too, use archaeologists for military intelligence.' Shall I go on? Because I can politically 'impeach' every Section of the British Association from A to X. This, I repeat, has nothing to do with party labels—although these are all too easy to attach, when we disapprove of someone's views. The mob which burned Priestley's home is metaphorically never very far away.

This is not a digression from my theme of 'The Fragmentation of Science.' It is, profoundly, a part of it. Because science is segregating itself into more and more compartments, because it is becoming more and more specialised, because in the process it is becoming less and less intelligible, and because in its diversity it is producing diverse results, it is creating and exacerbating the social stresses of our times. What people do not understand they fear, especially when, in ignorance, they see dire results. It is no good us saying 'Forget the atom-bomb. Remember penicillin.' It is human nature to take the good for granted and see only possible evil.

5. Scientists as Demigods

Because their discoveries so dominate the public imagination today, scientists have become a kind of demigods. Sometimes with the power they command, they feel that way—not in arrogance but with dread. When J. Robert Oppenheimer was hanging on to a post in the New Mexican desert waiting for the blast of the atom-bomb he had perfected, he, the student of Sanskrit, could think of only one thing 'as the brilliance of a thousand suns were burst at once into the sky.' He could think only of a quotation from the *Bhagavad Gita*, the Hindu Song of God, '*I am become Death, the shatterer of worlds.*' Terrifying, is it not, when a scientist could feel like Sri Krishna, Master of Man's Fate. But neither the man who directed the making of the bombs nor those who deploy them can willingly assume '*the Form of fire, world-wide, supreme, primeval*'. The burden of destruction by atomic means is too great for any man, for any group of men—too great for scientists, too great for statesmen, too great for generals. Here, thrust upon man, is a godlike decision—the judgment as to whether the greatest scientific discovery ever made is to be used for human holocaust or human betterment. We are at the moment trying to talk ourselves out of a nightmare, and a nightmare is the occasion for dreadful and irrational impulses not for sensible judgments. And judgments, in this case, can only come from an informed public, and only those who know the full implications can inform that public opinion. What the public is beginning to realise is that the scientists know that they (the scientists) do not know. On this issue, the greatest confronting mankind, the fragmentation of science is manifest. The public suspects —with justification—that the safebreakers got at the nucleus before the locksmiths knew how the wards worked. The fact that nuclear-physicists do not know the true nature of the nucleus does not alter the fact that we can explode a chain-reaction or control it safely, or that we can discharge a hydrogen bomb, but the *know-how* still does not mean the *know-all.* The public now sees even more clearly that while the physicists may know a great deal about the explosive forces (although we have had evidence that such forces, though theoretically not incalculable, can be miscalculated) they are certainly out of step with the biologists, who certainly do not know what the biological 'chain-reaction' will be. This divergence of the two branches, as Lord Adrian, our President last year, made clear and as a chorus of eminent voices have emphasised since, can mean the destruction of the human race, either deliberate or in ignorance, failing to refrain.

There is another warning which with deference I offer to scientists. I would revert to Dr. Oppenheimer. He was a scientist who because of his role in the creation of the bomb and because of his own scientific eminence and the popular eminence which was thrust upon him,

had a stature in his own country which few scientists have ever had in any country; it was this side idolatry. Consider what happened to him. I certainly do not propose to reopen the case, but merely to say that the 996 pages of the process of the inquiry should be compulsory reading for all scientists so that they may see how vulnerable they are when the mood of politics and the atmosphere of public opinion change. The whole history of that case is grim in its implications for science. It was not Dr. Oppenheimer who was being clawed down; it was science. People fear what they do not understand. They may reverence it with a kind of superstitious awe, but given the pretext they will tear down the idol. In this case, I suggest it was science, personified by Oppenheimer, which was being attacked. Of course, the atmosphere today is quite different and more tolerant, but I have no doubt that the mob which burned Priestley's home probably felt bewildered and shamefaced afterwards.

The point I want to emphasise is that if we create science into a mystery, because we cannot explain it, and if we treat scientists as geniuses or demigods instead of keeping them to life size, then they are always exposed to the risks of a revulsion of public feeling.

Putting it on a much cruder basis, science and scientists depend on the public purse for support. This applies to academic research as much as to government research or applied research in industry. The day of the private patron is over. The cost of endowing or equipping scientific research is beyond individual resources. Even the foundations are in a sense the public purse because it is a redirection of money which the Treasury might otherwise have claimed. But whether it is a matter of M.P.'s sanctioning grants or trustees approving endowments it depends very much on the attitude to science of laymen, in both those capacities. And particularly towards pure science. After all, applied science can be ' programmed ' to show dividends but pure science is an act of faith, and the public will go on signing blank cheques so long as, in the words of *1066 and All That*, science is A GOOD THING. In this country, I think we have every right and proper safeguard to ensure that academic research can be pursued without political pressures or interference, but there is always the ultimate sanction—the withholding of money. There are foreseeable circumstances in which Parliament—of course, stupidly—would decide that necessities came before the ' luxury ' of the pursuit of natural knowledge. That could not happen if it were fully realised.that academic research, even that which seems most remote from ' brass tacks,' is the source-spring of all research and progress. But I sometimes wonder what sort of case some of my inarticulate scientist-friends would present to any inquiry of laymen or what would be the reaction of such a body of laymen if it had paraded before them a procession of the fragmented sciences.

6. The Fencing-off of Science

Today we know more and share less. Once, as in The Lunar Society, we had the spirit of universal inquiry, which we have lost today in a world in which the common-ground of understanding has been fenced off into faculty estates, with a barrier wall between the humanities and science, and within the walls of science the ground has been sublet into plots with fences round them, too. The specialisation has been forced upon us by the rapid advance of science and technology, which has created such a vast amount of detailed knowledge that no one can encompass it. There are, today, over 40,000 scientific journals printing every year well over two million scientific contributions. At this meeting of the British Association there are over 300 papers.

In place of the free-ranging discussions with benign wine and gentle candlelight at the Lunar Society, we have narrower and narrower briefings in the ascetic glare of seminars and *colloquia* where, in their private jargon, the goobledygook of their specialities, scientists discuss last week's meson, the latest amino-acid synthesis, or a hair on the whisker of a banana-fly.

Learned societies, themselves ' splinter ' groups of natural philosophy, have sub-groups within groups and sub-sections within sections. It is not surprising, therefore, that the ordinary person thinks of science as a kind of vault of which only a B.Sc. knows the combination, and within

it a series of safes labelled ' Physics,' ' Chemistry,' ' Biology,' ' Geology,' ' Astronomy,' etc. And each of these has its special combination lock. And inside these safes there are lockers—vast numbers of lockers—marked ' Nuclear Physics,' ' Crystallography,' ' Solid State ' ; ' Colloid Chemistry,' ' Organic,' ' Inorganic ' ; ' Cytology,' ' Genetics,' ' Biophysics,' ' Biochemistry,' and so on *ad infinitum*. I do not believe that anyone, or any body, has ever made a complete list of all the so-called branches of science. What makes it worse, of course, is that each one invents its own private language. It would not be so bad if they would admit that it is their language of convenience, a shorthand, with grammalogues peculiar to the inventor and the small esoteric group around him, but so many scientists assume that their code-language is common language and that somehow people are ignorant or stupid if they do not understand. Much even of the normal language of science has been corrupted away from meaning by usage. It would be an excellent education and discipline for all scientists if they were to take their latest monograph, eschew all scientific terminology and use descriptive phrases instead —not for the edification of the public or even to oblige science-writers like myself, but for their own good. It is harsh but true to say that a scientist who cannot explain what he is doing, does not in fact know what he is doing. Every great scientist in my experience could explain —even Einstein tried ! Language, therefore, is one of the worst features of this fragmentation of science ; sometimes, I suspect, it is one of the causes of it.

' The trouble about science and scientific explanation is that it tends to be incomprehensible to anyone except the expert,' wrote Professor Hyman Levy recently in *Literary Guide* (June 1955). ' Scientists in transforming social life have enormously inflated the language. The influence of the Norman invasion on the English language has been profound ; yet how far-reaching the influence of modern science has hardly been assessed. Listen to a group of chemists or biologists or mathematicians talking among themselves and you will realise that most Englishmen today no longer know their mother tongue. Even a foreigner may understand more of what is said.' (Perhaps one should interpolate ' If the foreigner was a chemist, a biologist or mathematician of a particular school of chemistry, biology or mathematics.') Dealing with the ' language ' of mathematical symbols, Professor Levy asks : ' You say you want an explanation of Einstein's Theory of Relativity. What kind of explanation ? In terms of words of the Anglo-Saxon period and therefore with very nearly the concepts prevalent at that time ? In terms of the language of the seventeenth century and therefore with concepts prevalent about the time of Newton ? In terms of the language of, say, 1900 ? In modern technical terms ? In modern mathematical symbolism ? All these would represent attempts at explanation but how successful could they possibly be ? ' Or, I might add, in the terms of the language of a South Kensington bar where, over a glass of beer and bread and cheese, Professor Levy once gave me a ' translation ' of Einstein which made me sound very convincing that night on the B.B.C. I admit it was rather like getting a Cree Indian to define atomic energy—which I did recently. I found government geologists teaching Red Indian trappers in the Canadian North to look for uranium ore and I wondered just what it all meant to the Indians. I asked a chief what the Cree for atomic energy was. He replied, ' Eskotik-otchit kaochipyik,' which means ' Lightning that comes out of rock.'

I have dealt with semantics as a factor in the fragmentation of science because words are my stock-in-trade and because they form the barrier to public understanding and the bulkheads which separate the compartments of science, but there are other factors just as serious, or, indeed, more serious.

7. The Divorce from the Humanities

During this century, and particularly in the past twenty-five years, the gulf between science and the humanities has been widening. One might even date it with reasonable justification from 1900, when the first International Association of Academies met in Paris. Some of those academies had two sections, one scientific and the other for ' polite learning.' But the

Royal Society, 240 years removed from the days when its first fellows included Bishop Wilkins, Petty, the 'father' of political economy, Evelyn the diarist, Christopher Wren, the architect of St. Paul's, and Samuel Pepys, found that it now represented only one interest. It decided to restrict itself only to science and to reject the idea of forming a general academy and embracing the humanities. Instead it encouraged the formation of the British Academy 'For the Promotion of Historical, Philosophical and Philological Studies.' One can appreciate how experimental science, confident in the strength it had acquired in the nineteenth century, did not want any 'back-seat drivers.' Even 'Natural Philosophy,' although it continued titularly to dignify scientific chairs, had begun to sound archaic and the trend was already apparent by which science—which Comenius had claimed as 'the alphabet of divine wisdom' (in his dedication of *Via Lucis* to the newly founded Royal Society, 1668)—was to become an aggregation of discoveries.

There was also another trend. By the beginning of this century, the number of teaching laboratories in universities and schools was multiplying. This had a revitalising effect on education, but it was also the beginning of a process by which the science faculties in the universities and the 'science side' of the schools began to diverge from the arts. As scientific research increased, the science scholar had to learn more and more about his subject and less and less about the humanities. Science was no longer a 'bias'; it was a choice, almost a dedication. Today, as I go round schools and universities, I feel that the process has gone dangerously far. Science has become vocational training, certainly for pupils going on to higher education. I blame the universities. Because of the intense competition, on the science side, for entry to universities, it seems to me that the qualifications of entry are too high, too specialised. I should like to ask the university professors here whether, at the cost of a more general education, the Science Sixths are not now doing the work of the first and even second year university training.

As an outsider, I feel that youngsters are being 'rail-roaded' into science. At far too young an age, they are being labelled (like the evacuees during the war) and put on a train the destination of which has already been decided for them. It will take them through the Science Sixth and into the universities. If they are scientifically able they will be earmarked for post-graduate fellowships and switched on to the branch-line of some over-specialisation. I wish they could get off and hitch-hike occasionally. I sympathise with Lord Cherwell's complaint about science students having to waste their time in National Service—if it means square-bashing and peeling potatoes—but at least military training does interrupt this rail-roading; it gives them some contact with their fellows and a respite from talking 'shop.' I should have thought that some sort of National Service, which did not waste their aptitudes and usefulness, was healthy because it released students from this over-intensification. I would go further and argue that no one should go into postgraduate research until they have some 'field' experience. It is immaterial to my argument whether they go into teaching, into industry (if possible, not on the research side), into agriculture (not necessarily as farmhands), into the colonies as field-naturalists, field-geologists, engineers, and so on. It is immaterial because what I am asking for is a wider experience before they settle back again to specialisation. That happened in war when specialists were switched on to operational research or into spheres of science away from their speciality, where they could employ their scientific attitude and deploy their scientific knowledge. Does anyone dispute that that was good for them and good for the cause and good for science. That can happen in war, but a world war is an expensive way of 'limbering-up' science!

8. 'Know-hows' or 'Know-alls'?

My excuse—as an outsider—for making this earnest plea to our academic colleagues is that I am an expert on nothing except experts. My life is spent amongst them, not only in institutions of research but in the wider world. For the past ten years I have been engaged, mainly for the United Nations, in studying the problems of our underdeveloped world and the ways

in which science and technology can be employed in improving the lot of two-thirds of our fellow-humans, enhancing material progress, and employing, with wisdom, our natural resources. In this work of technical assistance, mutual aid, or whatever one cares to call it, I have met hundreds of experts in the out-of-the-way places of the world, in the deserts, in the tropics, in the Arctic. I know their qualities and I know their limitations. With conspicuous exceptions, who prove my point, their limitations derive from their *expertise*. They *are* experts, qualified in their specialisations and selected for their specialised experience. But they tend to think of themselves as 'know-alls,' rather than as 'know-hows,' in the sense that, preoccupied with their own subject, they think it is the exclusive answer. They are intent upon changing things without really knowing what they are changing. They confuse ignorance with lack of intelligence—considering people stupid who cannot grasp what is self-evident to those who have had perhaps ten or fifteen years of intensive specialised training. In 'Mutual Aid,' they have to be advisers not directors; they have to persuade and not dictate; they have to be aware of cultural patterns and traditions very different from their own. If they have not got this awareness of the wider implications of their work, all their knowledge and ability as experts is useless. They are merely conjurors doing their tricks, mystifying people but not equipping them to carry on where they leave off.

Does our system of scientific education provide the background—with its emphasis not only on the humanities but on humanity—which this kind of work, the expanding purpose of science, demands? I think not. But conversely, this work is one way of welding the fragmented branches of science. Men and women engaged on this work are becoming integrated and beginning to see the interrelation of their subjects. At the cost of over £30 million, we learned from the groundnut scheme that if you are going to bulldoze the scrub it is useful to have a naturalist around to remind you that in clearing the ground and getting rid of the tsetse fly you may also be getting rid of the pollinating bees, and that intimate knowledge of the local water-table may have more relevance than rainfall statistics. At immense cost engineers have been taught that their wonderful dams will silt up presently unless they team up with the plant ecologists and revegetate the eroding watersheds. In desert reclamation, we are beginning to cross-refer the work of desert experts of every continent, to realise that archaeologists studying ancient water-systems can substitute the experience of the ancients for the experiments of the moderns; that if we read the Old Testament as a source-book we can discover the historical, and present, significance of dew; and that our radioactive measurements of the presence of tritium in rainwater can decide the location of a desert well with some certainty of its regular replenishment. But this work in underdeveloped territories also demonstrates one of the dangers of the dichotomy of science—a danger as great as the time-lag between the physicists and the biologists in their knowledge of the effects of the atomic bomb. A similar time-lag exists between the advances in medical sciences —penicillin, D.D.T., etc.—and the agricultural sciences, which have to contrive to feed the mouths of those whose lives have been saved or whose expectation of life has been increased.

Because one saw the valuable lessons learned and contributions made in wartime, when scientists departed from their narrower specialities and were regrouped without much regard for the demarcations of their disciplines, and because one has seen the fruitful co-operation and realignment of scientists in the new war—War against Want—one feels the more the frustrations of the modern Babel. For the confusion of tongues was visited upon Babel because of its common purpose.

'*Behold, the people is one, and they have all one language . . . and now nothing will be restrained from them, which they have imagined to do.*'

9. The Brahmins of Science

There is another aspect of fragmentation and segregation which is, if you like, a by-product. It is what R. L. Meier (*British Journal of Sociology*, 1951, 11, 91–104) calls 'the social status attaching to certain branches of British science.'

'The Brahmins of contemporary British science' (according to Meier) 'are the mathematicians, the theoretical physicists, the chemists and geneticists. Feeling somewhat inferior to them are the ordinary organic chemists, metallurgists and biologists. Alienated from these but probably equivalent in rank are the advanced design engineers. In the third rank are the university graduates who are spending full-time accumulating and checking the practical information which will be the basis of industry, medicine and agriculture tomorrow. They are the applied scientists and engineers. Below them are the men who went to engineering and technical day-schools for several years and finally at the bottom is the more heterogeneous group which picked up its training as best it could at evening-classes and the industrial or trades courses. . . . Distinctions between these classes lie very deep in the English educational system (they are less marked in the Scottish). Many of the same tendencies are recognisable in the United States, especially in the eastern parts, but social mobility is far greater and more conscious efforts are made to eliminate class-distinctions.'

Each stratum (Meier points out) uses a different jargon, moves in its own social circle and has a recognised groove for promotion and advancement. A series of social misunderstandings and emotional blocks exist which make communications between specialists difficult, and (he claims) those social barriers are more important than British scientists and administrators realise. They are (he says) responsible for a great deal of friction and inefficiency in older research organisations and for the reluctance of those on the technical side of research in industry to consult the central research stations or research associations where, with a sense of inferiority, they would be dealing with university men. He also points out the social hierarchy in research establishments where deference to academic titles and degrees accentuates the social differences. I do not quote this as my own opinion but as a touchstone of agreement or disagreement which may sharpen our awareness of tendencies which grow with the fragmentation of science.

10. Summary

As the *agent-provocateur* let me reprovoke:

Scientists are becoming intellectual cripples. By the excess of specialisation forced upon them by the rapid advance of research and the vast literature of their subjects, they are using only part of their faculties and allowing the others to languish. They are so busy synthesising nature they have no time to synthesise their own science.

(i) Science by its emphasis on experimental research has forsaken natural philosophy, and in its hurried retreat from scholasticism is forgetting the scholarliness in which it made common ground with the humanities. By the same token, the humanities have lost touch with science. Overspecialisation gives the scientists the excuse for saying 'We have no time for other subjects,' and their colleagues in the arts the excuse for saying 'How can we understand.'

(ii) The fragmentation of science into more and more branches, each with their own specially invented jargon, is dividing the scientists and making it difficult and often impossible for one to understand the other, or to make themselves intelligible to the wider public.

(iii) This separation from the wider community is fraught with danger for our civilisation and for science itself. Science, which exists to remove mystery and magic, is creating its own mysteries and magic. People, in ignorance through lack of explanation, regard science with a kind of superstitious awe and, at the same time, expect science to produce those miraculous gadgets and 'cures,' which a certain type of popular journalism has taught them to expect and to take for granted. In the absence of a proper understanding of the methods and processes of science and of any social integration, the apparent haphazardness of discovery encourages a popular attitude toward science which is unhealthy and mistrustful. People fear what they do not understand.

(iv) Our educational system has become lopsided. Ignorance of the law is no excuse. Ignorance of science today should be no excuse. The first does not assume that everyone should be articled to a solicitor, and the second should not imply that everyone should be a B.Sc. Yet our

school and university system, by too-early and continuing segregation, gives too little science to one section of our citizenry and too much to another. This is as much a criticism of the humanities as it is of the science faculties.

(v) Lord Adrian, in his Presidential Address to the British Association, urged a common front with the social sciences. That is long overdue, but there is also a need for a common front between the natural sciences, exemplified in its extreme form in the fission and H-bombs, where the physicists have gone ahead of the biologists with the sombre risks which they forebode. A previous President, Professor A. V. Hill, also gave warning of the consequences of medical science outstripping the means to feed the lives we save.

11. Suggestions

Some may say that I have exaggerated the extent of the fragmentation, but few, I think, will dispute that it exists. It is easy to analyse what is wrong ; it is more difficult to suggest how it might be put right.

Basically it is a problem for education, not only in the scholastic sense, but of public information.

(i) As to how it might be dealt with in the schools and universities : I recommend, as a starting-point, the report of the British Association Committee on Post-War University Education (*The Advancement of Science*, Vol. III, No. 9). This committee, of which Dr. Maxwell Garnett was chairman and of which I had the privilege to be a member, and which included the representatives of the Allied Ministers of Education, met during the war. That report deserves re-examination, particularly its proposal for the institution of honours and pass schools of ' Philosophy, Natural and Social.' In spelling out the kind of course, we said : ' The study of natural science in such a course must be wider than any of the specialised science schools. . . .'

(ii) Such an advanced course should have its elementary counterpart in the schools as general instruction in what might roughly be called ' scientific method and social implications of science.' This would mean enough science to make it less intimidating to those who are not going to follow it and enough ' implications ' to make them aware that they must have a civic responsibility for its use, and not just blame the scientists for its misuse. In the U.S.A. this need is becoming recognised and I was invited to prepare a book for this purpose (*Science in Our Lives*, University of Michigan Press, and Signet. Published by George Allen and Unwin as *Science Makes Sense*). That book was a ' cockshy ' at what, I hope, our educators will do better and more thoroughly.

(iii) On the university level, Dr. James Conant, when he was President of Harvard, set an example, since followed by other universities in the U.S.A., of providing lectures on science to the liberal arts courses. In Britain, we have the new approach in the University College of North Staffordshire.

To meet my criticism of the experts, preoccupied with their *expertise*, there ought to be an extension of courses in social anthropology (preferably by some other name, since anthropology implies that they are going to study peoples rather than to work with them) for any experts —doctors, engineers, agronomists, etc.— going into the new fields of Mutual Aid.

(iv) On the subject of mass-information I commend a study of another British Association inquiry—the conference on ' Science and the Citizen ' held under the auspices of the Division of Social and International Relations in March 1943 (*Advancement of Science*, Vol. II, No. 8).

(v) Readers may be impressed by the British Association's awareness and prescience of the problem we are discussing. But three centuries ago Comenius had an awareness, too—in his proposal for the *Pansophicon*, his college at which the wise men of the world would come together, for a year at a time, and bring with them, and assess and explore, all natural knowledge, and propound it and make it widely known for the adoption by men for their benefit.

Somehow we must get this synthesis of scientific knowledge if science and humanity are to progress together and science can become wisdom.

REPORT OF COUNCIL TO THE GENERAL COMMITTEE, 1954–55

(Received and adopted by the General Committee on September 7, 1955)

Obituary

1. Since the Council's last report the Association has mourned the passing of Sir Arthur Keith, F.R.S., F.R.C.S. (Past President of the Association, 1927) and of Sir John Lennard-Jones, K.B.E., F.R.S. (Past General Secretary, 1946–47), and has suffered further loss by the death of the following office-bearers and supporters :—

E. Arnold Beech
Prof. W. S. Boulton
C. Augustus Carlow
Lt.-Col. P. J. Cowan, M.B.E.
Austin Eastwood
R. P. Foulds
Prof. F. E. Fritsch, F.R.S.
G. W. Grabham
Prof. P. J. Heawood
Prof. G. Hickling, F.R.S.
Prof. J. P. Hill
Prof. T. G. Hill
L. J. Hudleston
Miss E. V. Jenkins
Dr. J. Knaggs
Dr. G. M. Lees, M.C., D.F.C., F.R.S.
E. D. McCallum
Dr. W. T. Mathias
Sir Edward Mellanby, G.B.E., K.C.B., F.R.S.
Miss E. Pickering
Miss E. Pye
Dr. G. F. C. Searle, F.R.S.
Mrs. B. T. Shaw
Col. A. Stein
D. C. Thomson
Prof. Sir Godfrey H. Thomson

2. The Association was represented at the following memorial services : for Sir Arthur Keith, by Dr. E. Hindle and by other Members of the Council ; for Sir John Lennard-Jones, by Sir Richard Southwell ; and for Sir Edward Mellanby by Sir Robert Robinson, President of the Association.

Relations with other Institutions

3. Representatives of the Association were appointed by the Council as follows :

Ceylon Association for the Advancement of Science, Annual Meeting, November 1954. Sir Edward Bailey.

Indian Science Congress Association, Annual Meeting at Baroda, and Pakistan Association for the Advancement of Science, Annual Meeting, January 1955. Prof. W. H. Pearsall and Mr. A. M. Binnie.

French Association for the Advancement of Science, Annual Meeting at Caen, July 1955. Sir Robert Robinson and Sir Richard Southwell.

South African Association for the Advancement of Science, Annual Meeting at Grahamstown, July 1955. Prof. R. S. Adamson.

International Congress of Biochemistry, Brussels, August 1955. Sir Rudolph Peters.

National Committee for Geodesy and Geophysics. Sir Charles Normand.

Third Pan-African Congress on Prehistory, Livingstone, Rhodesia, July 1955. Mr. M. C. Burkitt.

4. Prof. W. H. Pearsall and Mr. A. M. Binnie conveyed, on behalf of the Council, the greetings of the British Association to the meetings of the Associations in India and Pakistan. Mr. G. A. Kellaway carried similar greetings on behalf of the Association to the Fifth Alaskan Science Conference which was held at Anchorage, Alaska, under the auspices of the American Association for the Advancement of Science. Through the courtesy of the British Council the greetings of the Association were presented to the Brazilian Association for the Advancement of Science at its Annual Meeting at Recife (June 1955).

5. The Officers have kept in touch with colleagues in other Associations for the Advancement of Science and representatives of many of those Associations, together with a number of other distinguished overseas scientists, will be entertained at Bristol. Professor Sydney Chapman and Dr. Lloyd Berkner, President and Vice-President respectively of the International Committee of the International Geophysical Year will also be the guests of the Association at Bristol.

6. The Council have offered twenty complimentary tickets for the Bristol Meeting to overseas science students. The British Council have most generously offered to supplement this award by providing accommodation or financial help where individual circumstances require it.

Unesco

7. The Council received from Unesco, and considered, terms of reference for the proposed Advisory Committee to the Director-General on the Public Understanding of Science. The Council agreed to nominate a representative to this Committee if it were constituted and if invited to do so.

The Council considered an invitation from Unesco to nominate a candidate for the award of the Kalinga Prize for 1955, and decided not to make any nomination.

Belfast Meeting, 1952

8. The Council is indebted to the Local Executive Committee in Belfast for the gift of £44 11*s.* 7*d.*, the balance of the Local Fund.

Oxford Meeting, 1954

9. The attendance at the Oxford Meeting was 2,925 members, a figure which included 685 student members. The Meeting was memorable in many ways, and the Council were pleased to learn that the Local Executive Committee had received many letters of appreciation since the Meeting from members at home and abroad.

Bristol Meeting, 1955

10. Occurring on the 800th anniversary of the granting of a charter to the city of Bristol, the 1955 Meeting (the fifth in Bristol) has a special interest. The Council are deeply appreciative of the warmth of local response to the Association's visit, and of the continued enthusiasm which has gone into the detailed planning of local arrangements. Innovations at Bristol will be a Schools Science Exhibition, the idea of which has been welcomed by the Local Executive Committee and by the Education Authorities in Bristol and the South-West, and daily screening of scientific films. Public Lectures have been arranged in advance of the meeting at Bath, Gloucester and Taunton.

Sheffield Meeting, 1956

11. An invitation to meet in Sheffield from August 29 to September 5 has already been accepted. A further report, which will include nominations of Local Officers, will be made to the General Committee at its first meeting in Bristol.

12. The following have accepted the Council's invitation to serve as Sectional Presidents for the Sheffield Meeting :

Section

A Sir George P. Thomson, F.R.S.
B Sir Charles Goodeve, O.B.E., F.R.S.
C Dr. T. Robertson
D Dr. W. H. Thorpe, F.R.S.
E Prof. A. Austin Miller
F (To be announced)
G A. C. Hartley, C.B.E.
H Dr. A. E. Mourant
I Dr. E. N. Willmer
J Prof. J. Drever
K Dr. H. Godwin, F.R.S.
L Sir Christopher Cox, K.C.M.G.
M G. V. Jacks

Assembly of Corresponding Societies: Dr. F. Sherwood Taylor.

13. *President*, 1956.—The Council will make a recommendation to the General Committee.

14. *General Officers*, 1955–56.—The Council have noted with regret the intention of Sir Richard Southwell, F.R.S., to retire after the Bristol Meeting. Sir Richard Southwell has served as Honorary General Secretary (Physical) since 1947, and the Council wish to place on record an expression of deep indebtedness to him for his devoted service to the Association.

The Council nominate for appointment as General Officers for the year 1955–56 :

General Treasurer : Mr. M. G. Bennett.
General Secretaries : Dr. George Taylor and Prof. W. Wardlaw, C.B.E.

15. *Other Members of Council*, 1955–56.—Members retiring under Statute III, 3, are:

Prof. L. Dudley Stamp, C.B.E., Prof. F. W. Paish, Prof. H. P. Gilding, Prof.

H. G. Champion, C.I.E., and Mr. A. Gray Jones. Under the powers given to them by statute the Council nominate for appointment: Mr. James Macdonald, C.B.E., Mr. J. N. L. Baker and Prof. E. A. G. Robinson, leaving two vacancies in the ordinary membership to be filled by the General Committee without nomination by the Council. The following is the full list of nominations recommended for approval by the General Committee (two names to be added):

J. N. L. Baker
R. J. Bartlett
Prof. L. F. Bates, F.R.S.
M. C. Burkitt
P. Ritchie Calder, C.B.E.
Prof. G. R. Clemo, F.R.S.
Dr. D. B. Harden
A. C. Hartley, C.B.E.
Prof. H. R. Hewer
Prof. L. Hunter
Prof. K. S. Isles
Dr. Willis Jackson, F.R.S.
Sir Harold Spencer Jones, K.B.E., F.R.S.
Prof. H. D. Kay, C.B.E., F.R.S.
Sir Ben Lockspeiser, K.C.B., F.R.S.
Prof. Kathleen Lonsdale, F.R.S.
Prof. A. D. Macdonald
James Macdonald, C.B.E.
J. Wickham Murray, O.B.E.
Dr. C. F. A. Pantin, F.R.S.
Prof. W. J. Pugh, O.B.E., F.R.S.
Dr. J. Ramsbottom, O.B.E.
Prof. E. A. G. Robinson
Dr. W. E. Swinton
Prof. P. E. Vernon
W. H. Wilcockson
Prof. S. W. Wooldridge, C.B.E.
Dr. N. C. Wright, C.B.

The General Committee approved the above nominations and appointed Prof. W. Burns and Sir Ronald Gould to fill the remaining vacancies.

(The Council have appointed Prof. L. Hunter to fill the vacancy which will arise when Prof. W. Wardlaw becomes General Secretary in succession to Sir Richard Southwell.)

16. *Honorary Auditors*, 1955–56: The Council recommend the reappointment of Sir John Simonsen, F.R.S., and Dr. H. J. T. Ellingham.

Dublin Meeting, 1957

17. The Council is pleased to report that the General Treasurer and the Secretary recently visited Dublin for preliminary discussions on the Meeting. They were received by the Lord Mayor of Dublin, the Provost of Trinity College, the President of University College, Professor T. S. Wheeler (University College) and Mr. G. F. Mitchell (Trinity College), and were assured of the welcome which awaited the Association's visit in 1957.

General Committee

18. The following have been admitted to membership of the General Committee on the recommendation of Section Committees:

G. R. Allen
Dr. R. Bainbridge
Dr. S. Bartlett
C. E. Beevers, C.B.E.
Prof. A. J. Brown
Prof. C. F. Carter
Dr. D. T. Donovan
F. H. Edmunds
Dr. B. H. Flowers
Dr. J. S. Forrest
D. F. Gibbs
J. C. Gilbert
W. J. Heasman
Prof. E. D. Hughes
Prof. F. E. Hyde
Dr. H. Kay
O. D. Kendall
Dr. H. L. Penman
Prof. R. J. Pumphrey, F.R.S.
J. C. Raven
Prof. G. L. S. Shackle
Dr. Edith Sheppard
R. M. Shone, C.B.E.
Dr. R. A. Smith
Prof. R. C. Tress
Prof. G. C. Varley
Prof. T. S. Wheeler
Dr. S. Whitehead
Prof. B. R. Williams
Dr. S. Wiseman

Presentation to Mr. D. N. Lowe, O.B.E.

19. Mr. D. N. Lowe, O.B.E., resigned his post as Secretary of the Association on March 31, 1954, on taking up appointment as Secretary of the Carnegie United Kingdom Trust. He was appointed Assistant Secretary in 1935, the year in which the Association met at Norwich, and in 1946, on his return from wartime service at the Ministry of Production, he succeeded Dr. O. J. R. Howarth, O.B.E., as Secretary of the Association. The years following the war were difficult ones for the Association and the marked success of post-war meetings was a tribute to Mr. Lowe's enthusiastic work and administrative ability. At the Oxford Meeting in 1954 the General Committee appointed him an Honorary Life Member of the

Association in formal recognition of his valuable services and of his devotion to the interests of the Association over a period of nearly twenty years.

Many members of the Association have since joined together in making a gift to Mr. Lowe as a token of their affection and esteem. The gift, in the form of a cheque, was sent to him with a letter of appreciation from the General Officers and Council of the Association.

Finance

20. The General Treasurer has kept the Council informed of the Association's finances and his Statement and Account for the financial year ending March 31, 1955, will be presented to the General Committee.

Division for the Social and International Relations of Science

21. The Committee of the Division, under the Chairmanship of Mr. P. Ritchie Calder, C.B.E., arranged a discussion of the problems of Land Use, to take place at Exeter on July 15 and 16.

A report of this Conference, with acknowledgments to all those who took part and helped with the organisation, will, it is hoped, be published after the Bristol Meeting.

Research

22. Following the Oxford Meeting, the Council appointed nine Research Committees on the recommendation of Sections and made grants to four of them. Details of the Committees, with their terms of reference, were published in *The Advancement of Science*, Vol. XI, No. 44, page 440.

Biological Stations

23. The Council have agreed that the annual grants of £50 for the rent of tables at Plymouth, Windermere and Naples should be renewed for 1955.

Science and Industry Committee

24. The Joint Science and Industry Committee has made substantial progress. The work of the research units at the University College of North Staffordshire and the Queen's University of Belfast is being supplemented by particular investigations carried out by sub-committees of the main Committee.

The funds available for the expenses of the Committee were increased by a Board of Trade grant for an extension of the main study on factors influencing innovation, together with the collection, in the course of the case studies, of material which would contribute to knowledge of the background of investment decisions. A grant was also made by the Human Relations Committee of the Department of Industrial and Scientific Research to enable the Science and Industry Committee to investigate problems in the adoption of new ideas and techniques which are not purely economic and financial.

The Council have appointed Dr. S. Whitehead to succeed Dr. T. E. Allibone, F.R.S., who has resigned from the Committee. A summary review of the initial work of the Committee is printed in *The Advancement of Science*, Vol. XI, No. 44, pages 404–408.

Memorial Lectures

25. Two of the three memorial lectures maintained by the Association are due to be delivered in 1955. The Council have appointed Professor Ian A. Richmond to deliver the Pedler Lecture at Bath on *Recent work on the Roman remains at Bath*, and Mr. F. Kingdon Ward the Lockyer Lecture at Taunton on a subject related to botanical exploration.

Publications

26. The Council have appointed the following as an Editorial Committee to deal with matters of editorial policy : Prof. L. Dudley Stamp, Dr. W. E. Swinton, Dr. H. Hamshaw Thomas and Prof. W. Wardlaw.

The Advancement of Science has been published regularly and has maintained a quarterly circulation of some 3,000 copies. The Association is indebted to the Local Executive Committee for the 1954 Meeting in Oxford, and, in particular, to the Delegates of the Clarendon Press, for their most generous gift at the end of the annual meeting of some 400 surplus copies of *The Oxford Region—a Scientific and Historical Survey*.

The Council report with pleasure that the initiative of colleagues in Bristol and

a generous grant from the Local Fund have made it possible to add another volume to the post-war series of Scientific Surveys of the regions of annual meetings.

Resolutions

27. Following discussions at the Oxford Meeting the Council received and considered a number of resolutions and recommendations with the following results :—

International Geological Map (Section C).—The Council approved a recommendation from Section C (Geology) that a grant of £20 from the Bernard Hobson Fund (reserved for geology) be made in support of the work of preparing a World Commission International Geological Map.

Scientific Surveys for Student Members (Section K).—It was noted that the Surveys were the gifts to the Association of the Local Executive Committee in the area visited, and that the generosity of the Oxford Committee had made it possible to offer a copy of the Oxford Survey to each of the student exhibitioners attending the meeting.

Lectures for Young People (Section L).—The Council were in general agreement with the recommendation of Section L (Education) that lectures for young people should be reintroduced in future programmes. The inclusion of two such lectures in the programme for Bristol has been agreed in consultation with the Local Officers and Education authorities.

Prizes

28. *South Africa Medal.*—The Council have approved the award of the South Africa Medal to Mr. D. E. Van Dijk for his paper on "The Tail of Ascaphus—a historical résumé and new histological-anatomical details."

Endeavour Essay Prizes, 1955.—The Council have welcomed the most generous offer, now made for the sixth time by the publishers of *Endeavour*, of prizes for scientific essays. In this, the sixth of the Endeavour Essay Competitions, the successful competitors were : Mr. A. N. Glazer (first), Mr. D. Hull (second), Miss I. A. Davies (third). Special prizes for competitors under eighteen years of age were awarded to Mr. I. F. Ross and Mr. P. I. Vardy.

Statutes and Regulations

29. The General Committee at Oxford asked the Council to reconsider the part of Section 22 of the Council's report to the General Committee (1953–54) on the Assembly of Corresponding Societies. The Council agreed that the word ' only ' be deleted from the phrase ' and the Council should invite this delegate *only* to join the General Committee.' (This amendment has been incorporated in the printed version of the report, which appears in *The Advancement of Science*, Vol. XI, No. 43, page 346. The effect will be that each Society will be represented by at least one delegate and that discretion is left to the Council to increase this number.)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

GENERAL TREASURER'S STATEMENT AND ACCOUNT, 1954–55

DURING the year ending 31st March, 1955, the General Income and Expenditure Account showed an excess of expenditure over income of £344. The improvement reported last year has therefore been maintained and the alarming divergence of 1953 has disappeared, at any rate for the present. The balance sheet remains steady largely because of the receipt of £650 on account of a legacy of £1,000 for general purposes provided under the Will of the late Mrs. C. E. S. Phillips. This generous legacy was most welcome and has more than offset the deficits of £288 in 1953/54 and £344 in 1954/55 on the general account for the past two years.

Donations totalling £80 were also received and they include one of £44, the unspent balance of the local fund raised for the 1952 Annual Meeting, and generously paid to the Association by the local Committee in Belfast.

Council authorised the expenditure of £375 from the accumulated income of the development fund for additional furniture, storage accommodation, shelving, etc., in the office in Burlington House and a marked improvement has been effected in both appearance and efficiency. With the approval of the University of Toronto, Council has decided to devote the Toronto Fund to the purchase of a presidential badge to be called the 'TORONTO BADGE,' which will be worn by the President of the Association on ceremonial occasions.

The position cannot of course be regarded as satisfactory while there is any adverse balance in the Income and Expenditure Account, particularly in view of gradual rising costs over the years. Of all the possible remedies, by far the most promising is the payment of subscriptions by covenant and by banker's order. The Association relies for its income chiefly upon membership subscriptions of one class or another, which run at about £6,000 a year. The tax recovered on covenanted subscriptions this year rose to £571, and there is no reason why it should not be trebled or more if everyone made it their business to try to push this form of payment. Further, if more members would pay their subscriptions annually, preferably by banker's order, even if they were not able sometimes to attend the Annual Meeting, the result could be substantial.

M. G. BENNETT,
General Treasurer.

Balance Sheet, 31st March, 1955

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES

	£ s. d.	£ s. d.
GENERAL PURPOSES :—		
Sundry Creditors	973 18 8	
Amounts received in advance for publications	202 2 4	
Membership and Associateship subscriptions in advance	122 3 0	
Amount temporarily held on behalf of Seismological Investigations Committee (Dr. J. E. Crombie's bequest)	1,000 0 0	
Cash overdrawn	199 4 6	
		2,497 8 6
Accumulated Fund		
As per last Account	40,661 8 9	
Less Excess of Expenditure over Income for the year on General Account	344 16 5	
	40,316 12 4	
Amount received on account of unconditional legacy of £1,000 under will of Mrs. Winifred Phillips	650 0 0	
		40,966 12 4
Life Membership Fund		
As per last Account	8,252 15 4	
Add Subscriptions received during year	189 0 0	
		8,441 15 4
[51,978 6 1]		51,905 16 2
Development Fund		
As per last Account	6,541 10 4	
Less Excess of Expenditure over Income for the year	103 17 4	
[6,541 10 4]		6,437 13 0
[58,519 16 5]		£58,343 9 2
SPECIAL PURPOSES :—		
Caird Fund		
Capital	9,511 9 11	
Income and Expenditure Account balance as per last Account	662 8 7	
Add Excess of Income over Expenditure for the year	77 15 10	
	740 4 5	
[10,173 18 6]		10,251 14 4
Toronto University Presentation Fund		
Capital	178 11 4	
Income and Expenditure Account balance as per last Account	4 15 3	
Add Excess of Income over Expenditure for the year	1 3	
	4 16 6	
[183 6 7]		183 7 10
Bernard Hobson Fund (1933)		
Capital	1,093 2 6	
Income and Expenditure Account balance as per last Account	315 11 9	
Add Excess of Income over Expenditure for the year	32 9 1	
	348 0 10	
[1,408 14 3]		1,441 3 4
Leicester and Leicestershire Fund (1933)		
Capital	1,000 0 0	
Income and Expenditure Account balance as per last Account	184 19 5	
Add Excess of Income over Expenditure for the year	15 9	
	185 15 2	
[1,184 19 5]		1,185 15 2
Radford Mather Lecture Fund (1936)		
Capital	242 18 0	
Income and Expenditure Account balance as per last Account	51 8 6	
Less Excess of Expenditure over Income for the year	13 2 2	
	38 6 4	
[294 6 6]		281 4 4
[13,245 5 3]	Carried forward	13,343 5 0

ASSETS

	£ s. d.	£ s. d.
GENERAL PURPOSES :—		
Investments as scheduled with Income and Expenditure Account, No. 1	51,373 14 0	
Sundry debtors	263 16 6	
Stock of Badges	268 5 8	
[51,978 6 1]		51,905 16 2
Development Fund		
Investments (see Income and Expenditure Account No. 2)	5,978 7 0	
Cash at bank	459 6 0	
[6,541 10 4]		6,437 13 0
[58,519 16 5]		£58,343 9 2
SPECIAL PURPOSES :—		
Caird Fund		
Investments (see Income and Expenditure Account, No. 3)	9,911 9 11	
Cash at bank	340 4 5	
[10,173 18 6]		10,251 14 4
Toronto University Presentation Fund		
Investment (see Income and Expenditure Account, No. 4)	178 11 4	
Cash at bank	4 16 6	
[183 6 7]		183 7 10
Bernard Hobson Fund (1933)		
Investments (see Income and Expenditure Account, No. 5)	1,243 2 6	
Cash at bank	198 0 10	
[1,408 14 3]		1,441 3 4
Leicester and Leicestershire Fund (1933)		
Investments (see Income and Expenditure Account, No. 6)	1,000 0 0	
Cash at bank	185 15 2	
[1,184 19 5]		1,185 15 2
Radford Mather Lecture Fund (1936)		
Investment (see Income and Expenditure Account, No. 7)	242 18 0	
Cash at bank	38 6 4	
[294 6 6]		281 4 4
[13,245 5 3]	Carried forward	13,343 5 0

Balance Sheet, 31st March, 1955 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES (*continued*)

		£ s. d.	£ s. d.
[*13,245 5 3*]	Brought forward		13,343 5 0
	Arthur Haydock Bequest **(1945)**		
	Capital	2,215 12 0	
	Income and Expenditure Account balance as per last Account	562 6 4	
	Add Excess of Income over Expenditure for the year	73 19 11	
		636 6 3	
[*2,777 18 4*]			2,851 18 3
	Corcoran Gift **(1946)**		
	Capital	100 0 0	
	Income and Expenditure Account balance as per last Account	13 0 4	
	Add Excess of Income over Expenditure for the year	3 5 1	
		16 5 5	
[*113 0 4*]			116 5 5
	Science and Industry Committee		
	Cash at bank as per last Account	136 15 2	
	Board of Trade grants	4,217 2 5	
	Department of Scientific and Industrial Research grants	538 0 0	
		4,891 17 7	
	Less Amounts transmitted to the Committee	4,891 17 7	
[*136 15 2*]			- - -
[*16,272 19 1*]			16,311 8 8

ASSETS (*continued*)

		£ s. d.	£ s. d.
[*13,245 5 3*]	Brought forward		13,343 5 0
	Arthur Haydock Bequest **(1945)**		
	Investments (see Income and Expenditure Account, No. 8)	2,465 12 0	
	Cash at bank	386 6 3	
[*2,777 18 4*]			2,851 18 3
	Corcoran Gift **(1946)**		
	Investment (see Income and Expenditure Account, No. 9)	100 0 0	
	Cash at bank	16 5 5	
[*113 0 4*]			116 5 5
	Science and Industry Committee		
	Cash at bank	- - -	
[*136 15 2*]			- - -
[*16,272 19 1*]			£16,311 8 8

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also verified the Balance at the Bankers and the Investments.

Approved:
J. L. SIMONSEN
H. J. T. ELLINGHAM } *Auditors.*

W. B. KEEN & CO., *Chartered Accountants,*
Finsbury Circus House, E.C.2.

15th June, 1955

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1955

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.	£ s. d.
	Investments at cost :		
	£8,264 4s. 4d. Consolidated 2½ per cent. Stock	6,401 3 0	
	£1,999 0s. 4d. British Gas 3 per cent. Stock, 1990/95	1,520 14 10	
	£18,400 0s. 0d. 3 per cent. Savings Bonds, 1965/75	19,098 11 9	
	£52 12s. 7d. 3½ per cent. War Stock (Post Office issue)	54 5 2	
	£7,704 6s. 2d. 3½ per cent. War Stock, 1952 or after	7,840 0 9	
	£6,768 15s. 7d. 3½ per cent. Conversion Stock, 1961 or after	5,726 8 11	
	£4,184 18s. 2d. 2½ per cent. Treasury Stock, 1975 or after	4,184 18 2	
	£1,400 0s. 0d. 4 per cent. Funding Loan Stock, 1960/90	1,622 0 0	
	£981 10s. 0d. 4 per cent. Commonwealth of Australia Stock 1955/70	1,000 0 0	
	£4,897 18s. 11d. 3 per cent. British Transport Stock, 1978/88	3,824 11 2	
	£100 0s. 0d. 3 per cent. Defence Bonds	101 0 3	
[*51,378 14 0*]	[*Value of stocks at 31/3/54, £45,488 11s. 4d.*] (Value at 31/3/55, £44,727 18s. 3d.)		£51,373 14 0

EXPENDITURE	£ s. d.	£ s. d.	INCOME	£ s. d.	£ s. d.
Heat, Lighting and Power (including £48 2 6 for new gas pipes)		182 10 3	Membership subscriptions		6,091 14 0
Stationery		438 17 0	Sale of Publications:		
Part cost of addressing machine		40 10 0	"The Advancement of Science"	749 13 1	
Rent		1 0 0	Other items	118 10 4	
Postages		416 12 4			868 3 5
Telephone		38 17 7	Advertisements in B.A. publications:		
Insurances		11 18 8	"The Advancement of Science"	684 18 8	
Travelling expenses		385 17 0	Preliminary Programme, 1954	219 14 4	
Audit for 1953-54		115 10 0	Programme, 1954	416 10 4	
Exhibitioners:	153 15 3				1,321 3 4
Less Contribution by Liverpool University	50 0 0		Income Tax recovered to 31st March, 1954:		
		103 15 3	On Interest and Dividends	117 15 1	
Subscription to Parliamentary and Scientific Committee		15 15 0	„ covenanted subscriptions	571 4 4	
Hire of meeting rooms, equipment, etc.		32 12 6			688 19 5
Lift Inspection and Repairs		16 18 3	Interest on Investments		1,593 0 0
Carriage of goods		32 4 10	Donations		80 2 7
Reference books, press cuttings, etc.		37 10 10	Charges for administration of Special Funds		74 2 1
General expenses		81 2 7	[*10,733 1 7*]		10,717 4 10
Panels of armorial bearings		14 1 0	Balance, being excess of Expenditure over Income for the year		344 16 5
Salaries, wages, pensions and National Insurance		4,520 16 4	[*288 14 0*]		
Printing, etc.—					
"The Advancement of Science"	2,676 18 1				
Preliminary Programme, 1954	421 15 5				
Programme, 1954	675 2 7				
Miscellaneous	410 13 10				
		4,184 9 11			
Hospitality		218 15 2			
Membership badges used		123 5 9			
Legal advice, etc. (balance)		9 0			
Typing etc., by outside offices		48 12 0			
[*11,021 15 7*]		£11,062 1 3	[*11,021 15 7*]		£11,062 1 3

No. 2. Development Fund

An Appeal for a Development Fund to be used under the direction of the Council, was made at the Annual Meeting at Dundee in 1947. The fund is still open.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,745 19s. 0d. London County 2½ per cent. Consolidated Stock, 1960/70	2,750 0 0
	£3,387 14s. 10d. Savings 3 per cent. Stock, 1965/75	3,028 7 0
	£292 15s. 3d. Consolidated 2½ per cent. Stock	200 0 0
[*Value of stocks at 31/3/54, £5,666 4s. 5d.*]	(Value at 31/3/55, £5,559 5s. 11d.)	
[*5,978 7 0*]		£5,978 7 0
	Cash at bank	£459 6 0

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Office alterations, shelving, furniture and equipment [– – –]	323 0 2	Dividends and Interest	184 9 2
Administration charge [*20 13 7*]	24 7 0	Income Tax recovered [*206 15 11*]	59 0 8
Balance, being excess of Income over Expenditure for the year [*186 2 4*]	– – –	Balance, being excess of Expenditure over Income for the year [– – –]	103 17 4
[*206 15 11*]	£347 7 2	[*206 15 11*]	£347 7 2

No. 3. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,904 11s. 8d. British Gas 3 per cent. Stock, 1990/95	2,209 13 0
	£2,716 16s. 6d. 3½ per cent. War Stock	2,516 15 5
	£4,282 18s. 9d. 3 per cent. British Transport Stock, 1978/88	4,785 1 6
	£585 10s. 6d. Consolidated 2½ per cent. Stock	400 0 0
[*Value of stocks at 31/3/54, £8,910 19s. 5d.*]	(Value at 31/3/55, £8,667 4s. 6d.)	
[*9,911 9 11*]		£9,911 9 11
	Cash at bank	£340 4 5

EXPENDITURE	£ s. d.	£ s. d.	INCOME	£ s. d.
Rent of tables for 1955 at Biological Stations:			Dividends and Interest	267 10 4
Naples Zoological Station	50 0 0		Income Tax recovered	57 16 2
Freshwater Biological Association, Windermere	50 0 0			
Marine Biological Association, Plymouth	50 0 0			
		150 0 0		
Grants to Research Committees:				
Inventoria Archaeologica	15 10 0			
Demography, etc., in Inter-Tropical Africa	4 10 0			
Ainu of Japan	45 0 0			
		65 0 0		
Administration charge		32 10 8		
[*255 6 7*]		247 10 8		
Balance, being excess of Income over Expenditure for the year [*93 18 5*]		77 15 10		
[*349 5 0*]		£325 6 6	[*349 5 0*]	£325 6 6
Grants authorised, not yet drawn :—				
Inventoria Archaeologica	5 0 0			
Glossary of Geographical Terms	5 0 0			
[*12 19 4*]	£10 0 0			

No. 4. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. In June 1954 the Council, with the approval of the University of Toronto, decided to expend the fund on the purchase of a Presidential Badge to be called the Toronto Badge, instead of providing two bronze medals annually together with books for presentation to selected students.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£175 0s. 0d. 3½ per cent. War Stock	178 11 4
	[*Value of stock at 31/3/54,* £152 5s. 0d.] (Value at 31/3/55, £149 12s. 6d.)	
£178 11s. 4d.]		£178 11 4
	Cash at bank	£4 16 6

	£ s. d.		£ s. d.
EXPENDITURE		**INCOME**	
Cost of medals for 1954	5 9 0	Interest [6 2 6]	6 2 6
Presents of books [– – –]	– – –		
Administration charge [6 5 3]	12 3		
	6 1 3		
Balance, being excess of Income over Expenditure for the year [– – –]	1 3	Balance, being excess of Expenditure over Income for the year [– 2 9]	– – –
[6 5 3]	£6 2 6	*[6 5 3]*	£6 2 6

No. 5. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£50 0s. 0d. 4 per cent. Victory Bonds	55 10 5
	£601 9s. 0d. 2½ per cent. Treasury Stock, 1975 or after	601 9 0
	£416 0s. 11d. 3½ per cent. War Stock	436 3 1
	£178 16s. 4d. Consolidated 2½ per cent. Stock	150 0 0
	[*Value of stocks at 31/3/54,* £917 7s. 5d.] (Value at 31/3/55, £889 18s. 1d.)	
[1,243 2 6]		£1,243 2 6
	Cash at bank	£198 0 10

	£ s. d.		£ s. d.
EXPENDITURE		**INCOME**	
Grants [30 0 0]	– – –	Interest	36 1 2
Administration charge [3 12 1]	3 12 1		
Balance, being excess of Income over Expenditure for the year [2 9 1]	32 9 1		
[36 1 2]	£36 1 2	*[36 1 2]*	£36 1 2
Grants authorised, not yet drawn :—			
Critical Geological Sections 30 0 0			
International Geological Map 20 0 0			
[30 0 0]	£50 0 0		

No. 6. Leicester and Leicestershire Fund, 1933

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£487 2s. 11d. 3½ per cent. Conversion Stock	500 0 0
	£490 5s. 11d. 3½ per cent. War Stock	500 0 0
	[*Value of stocks at 31/3/54,* £847 17s. 9d.] (Value at 31/3/55, £835 14s. 4d.)	
[1,000 0 0]		£1,000 0 0
	Cash at bank	£185 15 2

	£ s. d.		£ s. d.
EXPENDITURE		**INCOME**	
Grant to A. Datyner [– – –]	30 0 0	Interest	34 4 2
Administration charge [3 8 5]	3 8 5		
Balance, being excess of Income over Expenditure for the year [30 15 9]	15 9		
[34 4 2]	£34 4 2	*[34 4 2]*	£34 4 2

No. 7. Radford Mather Lecture Fund

A gift of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£271 14s. 6d. Savings 3 per cent. Stock, 1965/75	242 18 0
	[*Value of stock at 31/3/54, £243 3s. 10d.*] (Value at 31/3/55, £240 9s. 6d.)	
[*242 18 0*]		£242 18 0
	Cash at bank	£38 6 4

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Lecture fee and fare	22 1 10	Interest	8 3 0
[– – –]		[*9 14 2*]	
Administration charge	1 0 0	Income Tax recovered	1 16 9
[*– 19 5*]		Balance, being excess of Expenditure over Income for the year	13 2 2
Balance, being excess of Income over Expenditure for the year	– – –	[– – –]	
[*8 14 9*]			
[*9 14 2*]	£23 1 10	[*9 14 2*]	£23 1 10

No. 8. Arthur Haydock Bequest

A bequest received in 1945 "for the purpose of original investigation of problems relating to either or both of Geology or Botany as may be determined by the governing body of the British Association."

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,090 4s. 0d. 3½ per cent. Conversion Stock .	2,215 12 0
	£362 6s. 3d. Consolidated 2½ per cent. Stock .	250 0 0
	[*Value of stocks at 31/3/54, £2,043 10s. 7d.*] (Value at 31/3/55, £2,017 3s. 9d.)	
[*2,465 12 0*]		£2,465 12 0
	Cash at bank	£386 6 3

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Grants	– – –	Interest	82 4 4
[*5 0 0*]			
Administration charge	8 4 5		
[*8 4 5*]			
Balance, being excess of Income over Expenditure for the year	73 19 11		
[*68 19 11*]			
[*82 4 4*]	£82 4 4	[*82 4 4*]	£82 4 4

No. 9. Corcoran Gift

A gift of £100 received in 1946 for research in memory of Miss J. R. Corcoran.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost:	
	£144 18s. 6d. Consolidated 2½ per cent. Stock	100 0 0
	[*Value of stock at 31/3/54, £94 4s. 0d.*] (Value at 31/3/55, £92 0s. 7d.)	
[*100 0 0*]		£100 0 0
	Cash at Bank	£16 5 5

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Administration charge	7 3	Interest	3 12 4
Balance, being excess of Income over Expenditure for the year	3 5 1		
[*3 12 4*]	£3 12 4	[*3 12 4*]	£3 12 4

SEISMOLOGICAL INVESTIGATIONS

SIXTIETH REPORT of COMMITTEE on Seismological Investigations. (Dr. R. STONELEY, F.R.S., *Chairman*; Mr. E. TILLOTSON, *Secretary*; Mr. E. F. BAXTER, Miss E. F. BELLAMY, Prof. P. G. H. BOSWELL, O.B.E., F.R.S., Mr. B. C. BROWNE, Sir E. C. BULLARD, F.R.S., Dr. K. F. CHACKETT, Dr. G. E. R. DEACON, C.B.E., F.R.S., Dr. A. T. J. DOLLAR, Dr. A. E. M. GEDDES, O.B.E., Prof. G. R. GOLDSBROUGH, C.B.E., F.R.S., Dr. M. N. HILL, Mr. J. S. HUGHES, Prof. Sir H. JEFFREYS, F.R.S., Dr. E. R. LAPWOOD, Dr. A. W. LEE, Dr. A. O. RANKINE, O.B.E., F.R.S., Rev. C. REY, S.J., Dr. G. D. ROBINSON, Mr. H. V. SHAW, and Sir FRANK E. SMITH, G.C.B., G.B.E., F.R.S.)

THE GRAY-MILNE FUND

The only disbursements during the past year have been for secretarial expenses, but the expenditure on a new driving-clock for the Milne-Shaw seismograph at Suva has been sanctioned in replacement of the one completely worn out. The sum of £400 remains invested in Defence Bonds, and the Crombie bequest of £1,000 has been left in the custody of the Treasurer of the Association.

GRAY-MILNE FUND

Receipts

	£	s.	d.
Balance at Bank, July 1, 1954	530	18	3
Trust Income . . .	80	14	10
Interest on Defence Bonds .	10	0	0
	621	13	1

Payments

	£	s.	d.
Stamps on cheques . .		4	0
Secretarial expenses . .	11	18	4
Balance at Bank, July 21, 1955	609	10	9
	621	13	1

INSTRUMENTS

There has been no change in the location of the instruments belonging to the committee during the past year. A new driving-clock is on order for Milne-Shaw seismograph number 63 at Suva, Fiji. The instruments are located as follows :—

Milne-Shaw Seismographs :

No. 1. Science Museum, South Kensington.
„ 3. Edinburgh.
„ 4. Downe, Kent (in storage).
„ 6. Hermanus, South Africa.
„ 27. Perth, Western Australia.
„ 63. Suva, Fiji.

Jagger Shock Recorder, Fort Augustus.

INTERNATIONAL SEISMOLOGICAL SUMMARY

By J. S. Hughes

The work on the seismological summary for June 1947 is in hand, the first five months of the year being ready for press, and the third quarter for 1946 will be distributed shortly. Though progress is up to schedule for the year, periods of unavoidable delay have occurred which have made publication irregular.

The presentation of observations remains the same and the Bureau of Geophysics at Strasbourg continue to supply macroseismic information and references for inclusion.

The staff continue to enjoy the hospitality of the Meteorological Office at Kew Observatory. Mrs. Saunders is in charge of the clerical and secretarial side, and Mr. J. D. Wavish, B.A. (Hons.) Lond., has been graduate assistant since October 1954. At the moment there is no junior clerk, but it is intended to engage a suitable candidate when occasion arises. Mrs. Sykes is again assisting extra-murally

with copying of observations, a necessary but somewhat tedious part of the routine. There is a conspicuous increase in the number of observations received which are not suitable for determination of epicentre. Groups of well-equipped stations in close proximity to one another tend to record the same phases of an earthquake. Though apparently constituting a large block of observational data, these tend to be the equivalent of one first-class station when used to study an epicentre at a distance. Though not adding any special difficulty, this does involve an increase in the amount of material to be investigated, which is not balanced by the increase in the number of epicentres that can be determined.

DEPARTMENT OF GEODESY AND GEOPHYSICS, CAMBRIDGE

(*Director : Mr. B. C. Browne*)

SEISMOLOGY—EXPERIMENTAL (*Dr. M. N. Hill*). Seismic refraction shooting experiments have, this year, been confined to the English Channel and the Western Approaches. From the results obtained at a line of stations extending down the middle of the English Channel from the Greenwich Meridian to the longitude of Weymouth it was found that the depth to the Palaeozoic floor varied between 2,400 and 3,500 feet. These figures are smaller than had been expected. The development of the long-period seisomgraph continues.

SEISMOLOGY — THEORETICAL (*Dr. R. Stoneley, F.R.S.*). Dr. Stoneley has investigated the problem of the propagation of surface waves in a medium with cubic symmetry, the free surface of which is a principal plane. The propagation of waves of Rayleigh type is not possible for all values of the density and the three elastic constants ; but when it is possible, the wave velocity depends on the direction of propagation. For the symmetrical cases of transmission along a principal axis or along a bisector of two perpendicular principal axes in the free surface, Rayleigh wave motion can occur, in which the particles describe ellipses in a retrograde direction. In these cases only can transverse motion (as in Love waves) exist by itself. In the general case, the plane of the particles is inclined to the plane of propagation, and, in fact, the separation in an isotropic solid into Rayleigh waves and transverse motion occurs as a mathematically degenerate case of this general type of motion.

DURHAM UNIVERSITY OBSERVATORY, JULY 1955

By Mr. E. F. Baxter

The building of an underground chamber for the seismographs started in the spring and is due for completion by the end of the year. It is promised that the diurnal temperature variation will not exceed 1° F. This should improve enormously the recordings from the Milne-Shaw seismographs, which now suffer from apparent irregular disturbance due to air-currents generated by temperature changes, and from drift of the light spot due to change in the equilibrium position of the boom at least partly due to differential expansion arising from temperature changes.

A provisional order has been placed for a Wilson-Lamison vertical seismometer and G.E. galvanometer from the U.S.A. After very considerable delays and enquiries an import licence was obtained from the Ministry of Supply, but matters of price have yet to be settled. The U.S.C.G.S. have been, and are being, most helpful in the whole matter and have offered to test the seismometer coupled to the galvanometer before despatch.

THE NATIONAL INSTITUTE OF OCEANOGRAPHY

(*Director : Dr. G. E. R. Deacon, C.B.E., F.R.S.*)

Mr. Darbyshire has calculated refraction diagrams for microseismic waves approaching Bermuda on the assumption that they are surface waves between the ocean and the sea-bed of the type described by Stoneley. The diagrams show that the refraction of energy away from the island is very marked for waves approaching from the north-east and south-west. This effect explains some of the anomalies observed at Bermuda, in one of which a storm slightly to the west of

north gave large microseisms, while one slightly to the east of north had little effect. The work shows that the study of recordings at islands must take account of refraction. A paper by Mr. Darbyshire giving details of the study and conclusions will be published shortly by the Royal Astronomical Society.

EARTH TILTS IN THE BRITISH ISLES CONNECTED WITH FAR-DISTANT EARTHQUAKES

By Prof. Dr. R. Tomaschek (British Petroleum Co. Ltd. Research Station, Kirklington Hall, nr. Newark).

The earthquake of October 21, 1951, 21h. 34 G.M.T., Formosa (122° E., 24° N.) magnitude 7, was followed by remarkable earth tilts in the British Isles as observed with the tiltmeters installed at Winsford (Cheshire) at a depth of 450 feet below surface. They occurred in two stages; the first amounted to 0.04 sec. of arc lasting about five hours after the first arrival of the earthquake. After a fairly quiet time of about seventeen hours a strong tilt movement started which lasted about thirteen hours and settled down to a slow drift for the next twenty-four hours. The total tilt within thirty-six hours amounted to about 0.2 sec. of arc of dipping down towards north-west. The tilt records at Bidston also show the disturbance very clearly. These tilts coincide with those observed by Nishimura in Japan as a consequence of this earthquake. A world-wide readjustment in the Earth's crust seems to have taken place, similar to that observed by Benioff with his strain meter at Pasadena as a consequence of the Kamtschatka earthquake of November 1952.

BRITISH EARTH TREMORS

By Ernest Tillotson

Two earth tremors occurred in the southern part of the West Riding of Yorkshire on October 23, 1954. These were felt at Hemsworth and South Elmsall, but there are no reports of them having been felt at Pontefract, which is nearby. The Superintendent of Police at Pontefract kindly assisted in making enquiries concerning the macroseismic effects of the shocks and positive evidence was obtained. Police Sergeant John Thomson reported that the first tremor was felt at Hemsworth after 1 P.M. and the second some twenty or thirty minutes later, the first being the greater. 'In the first one, which lasted about two seconds, several buildings were shaken, especially in Market Street, and crockery on the lunch-tables rattled and shook. The second tremor, which lasted only about a second, could be felt.'

Mr. J. Willey, of Station Road, South Elmsall, felt only one shock, shortly after 1.15 P.M.: '. . . and as the tremor passed under the house the floor appeared to move under my feet, and the bottles (on the sideboard) actually clinked against each other. There appeared to be a distinct rumble—like a steamroller passing the house. It certainly was a rather disturbing experience and rather similar to a small earthquake my wife and I experienced whilst staying at Vina del Mar in Chile in 1949.'

Many people in South Elmsall felt the shock, which is believed to have travelled down the valley from the west, from Pontefract or Hemsworth. Police Inspector E. Lancaster, of South Elmsall, states that the first shock only was felt at Moorthorpe Police Station, and writes: 'Local opinion . . . was that the shock was caused by a weight bump which occurs when the strata above pit workings collapses. I have spoken to Mr. Evans, the Agent at Frickley Colliery, and he states that no evidence was found in the workings that the shock was a weight bump.' At the epicentre the shock appears to have had strength III on the Modified Mercalli Scale.

The instrumental recordings have been studied by Mr. E. F. Baxter, of Durham University Observatory, and are given below.

Following Col. Tillotson's article, 'Earthquakes during October 1954–January 1955' in *Nature* of April 2, a search was made on the Durham seismograms and a tremor which might have been due to a near earthquake was detected at 13.26.34 on the E.W. record and at 13.26.37 on the N.S. record. Enquiries made to Kew and Rathfarnham (Dublin) confirmed the earthquake, although neither Kew or Rathfarnham had

READINGS

Station	*Distance*	*Time and component*		*Phase*	*O—C*
Durham	1° 10′	13.26.34	E	Pg	0
		13.26.37	N	?	
Kew	2° 13′	13.26.54	ZN	Pg	0
		13.27.15·5	E	Sn	−1
Rathfarnham	3° 00′	13.27.31	Z	?	
		13.27.33·5	Z	?	
		13.27.35	Z	Sn	−2
		13.27.43	Z	S*	0

reported the tremor in their bulletins. The local reports and the Durham, Kew and Rathfarnham readings best accord with epicentre at 53° 36′ N., 01° 19′ W., time of origin 13.26.10, though this leaves the early Rathfarnham phases unidentified.

The shock was not recorded by the seismograph at the Royal Observatory, Edinburgh.

On Monday, November 15, 1954, a slight earth tremor shook the village of Winster and surrounding villages in Derbyshire. The shock rattled doors, windows and crockery, but did no apparent damage. A ' crump '-like sound preceded the tremor.

On Monday, August 22, 1955, shortly after midday, an earth tremor was felt at Aberdovey, Merioneth.

INTERNATIONAL CO-OPERATION

By R. Stoneley

A number of the members of this committee attended the Tenth General Assembly of the International Geodetic and Geophysical Union in Rome, September 14–25, 1954. The programme of the Assembly was a very full one, and was notable for the number of interesting and successful symposia and joint meetings of Associations. For the first time since the war Russian geophysicists were present, attending by invitation ; in particular the names of Prof. Vladimir Beloussov, of the Moscow Academy of Sciences, and Prof. Georgy Gorshkov, of Moscow State University, may be mentioned. The Assembly was preceded by a reunion of the European Seismological Commission, under the presidency of Prof. W. Hiller.

The proceedings of the Association of Seismology and the Physics of the Earth's Interior opened with a presidential address by Prof. B. Gutenberg on the Effects of Low-velocity Layers, and joint meetings were held as under :

Snow and Ice (with Hydrology).
Radioactivity (with Vulcanology).
Movements in the Earth's Core : Electrical Conductivity (with Terrestrial Magnetism).
Constitution of the Earth, and Dissipation of Energy (with Vulcanology).
Isostasy (with Geodesy).
Geothermy (with Vulcanology).
Gravimetric and Seismic Interpretation: Variation of Latitude (with Geodesy and Vulcanology).

In addition to special sessions on Apparatus, on Microseisms and on Seismography, the grouping of papers under headings gave the meetings more of the character of symposia. The considerable development of seismology in recent years was evident. The Officers elected for the present triennium were : President : Prof. K. E. Bullen ; Vice-Presidents : Prof. E. Wanner, Prof. K. Wadati ; General Secretary : Prof. J.-P. Rothé. Sir Harold Jeffreys continues as Honorary Director of the International Seismological Summary.

EDINBURGH SEISMOGRAMS

The Honorary Secretary has now read the Edinburgh seismograms to the end of the year 1951. The work is continuing.

MEMBERSHIP

The committee proposes that Dr. E. R. Lapwood be appointed a member of the committee.

BRISTOL MEETING
SECTIONAL TRANSACTIONS

Any references to publications supplied by authors will be found on pages 363 to 368.

SECTION A
MATHEMATICS AND PHYSICS

September 1

Prof. C. F. Powell, F.R.S.—*Cosmic Rays.*

Dr. B. H. Flowers.—*Fundamental particles produced by high energy machines.*

September 2

Physics of the Solid State, Presidential Address by Prof. N. F. Mott, F.R.S.

Dr. A. H. Cottrell, F.R.S.—*Behaviour of metals inside atomic piles.*

Dr. N. Thompson.—*The physics of metal fatigue.*

Prof. S. Chapman, F.R.S.—*The international geophysical year—its objectives and scope.*

Dr. W. J. G. Beynon.—*Ionospheric studies during the international geophysical year.*

Dr. R. L. F. Boyd.—*Research with rockets* (followed by a film : Horizon Unlimited).

September 5

Session A

The training of the physicist. (Joint Session with Section L—(Education).)

Sir Philip Morris, C.B.E.—*A scientific education.*

Prof. N. F. Mott, F.R.S.—*Specialisation in school and university.*

Prof. F. A. Vick.—*Education through physics.*

Dr. A. W. Barton.—*The function of the school in discovering and training physicists.*

Session B

Flames and Combustion:

Dr. A. G. Gaydon, F.R.S.—*The structure of flames.*

Dr. F. J. Weinberg.—*The study of flames by optical methods.*

Dr. B. P. Mullins.—*Combustion and the aircraft gas-turbine.*

Prof. M. W. Thring and Dr. C. Hulse.—*The part played by luminous radiation in furnace heat transfer.*

September 6

Heredity and the structure of DNA (in association with Sections D (Zoology) and K (Botany).)

Prof. J. B. S. Haldane, F.R.S.—*The biology of DNA.*

Prof. J. N. Davidson.—*The biochemical basis of cell structure.*

Dr. M. F. H. Wilkins.—*Experimental evidence on the molecular structure of nucleic acids and chromosomes.*

Dr. F. H. C. Crick.—*The replication of DNA.*

September 7

Mr. D. P. C. Thackeray.—*High-speed photography.*

Dr. V. E. Cosslet.—*Electron-microscopy.*

SUB-SECTION A *
MATHEMATICS

September 1

Prof. R. L. Goodstein.—*The decision problem.*

Mr. J. C. Shepherdson.—*The application of symbolic logic to algebra.*

September 5

Mr. D. G. Kendall.—*Stochastic processes.*

September 6

Prof. L. Howarth, O.B.E., F.R.S.—*Shock waves.*

SECTION B
CHEMISTRY

September 1

Nucleic acid structure and function, Presidential Address by Sir Alexander Todd, F.R.S.

Prof. M. Stacey, F.R.S.—*Taking the nucleic acid jackets off bacteria.*

Prof. C. D. Darlington, F.R.S.—*Nucleic acid: the midwife molecule.*

September 2

Some aspects of the chemistry of colonial products:

Sir John Simonsen, F.R.S. (*Chairman*).

Dr. R. A. E. Galley.—*Introduction.*

Prof. C. H. Hassall.—*Medicinal products from tropical plants.*

Dr. W. G. C. Forsyth.—*Cocoa: a question of taste.*

Dr. P. C. Spensley.—*Drugs from a vegetable waste.*

September 5

Marine organisms and biogeochemistry. (See entry under Section D.)

Sorting Molecules:

Prof. W. Baker, F.R.S.—*Chairman's Introduction.*

Dr. F. H. Pollard.—*Separation of volatile substances by differing rates of migration.*
Mr. H. M. Powell, F.R.S.—*Sorting molecules by shape and size.*
Prof. R. M. Barrer.—*Separation of molecular mixtures using crystal sieves.*

September 6

The Teaching of Chemical Principles in School and University. (Joint session with Section L (Education)) :
Prof. D. H. Everett, M.B.E.—*Introductory paper.*
Prof. C. A. Coulson, F.R.S.—*The teaching of quantum mechanics.*
Mr. G. I. Brown.—*The teaching of modern valency theory in schools.*

SECTION C

Geology

September 1

Prof. W. F. Whittard.—*The geology of the Bristol district.*
Mr. G. A. Kellaway.—*The Upper Palaeozoic stratigraphy of the Bristol district.*
Miss P. Lamplugh Robinson and Dr. K. A. Kermack.—*Some evolutionary missing links from fissures in the Bristol channel area.*

September 2

Session A

Structural petrology and problems of the Caledonides.
Dr. F. C. Phillips.—*Introduction.*
Mr. J. M. Christie.—*Tectonic phenomena associated with the post-Cambrian movements in Assynt.*
Mr. P. Wilkinson.—*Structure and tectonic history of the Eriboll region, Sutherland.*
Mr. C. B. Crampton.—*Some aspects of Moine and Cambrian fabrics in the region bordering Sutherland and Ross.*
Mr. M. R. W. Johnson.—*Time sequences of folding, recrystallisation and thrusting in the Kishorn and Moine nappes, Loch Carron and Coulin Forest, Wester Ross*
Mr. D. C. Goldring.—*Structural petrology of the Dalradian schists of north-east Antrim.*

Session B

The stratigraphy and palaeontology of the Ludlovian:
Dr. J. D. Lawson.—*Introduction : the aims and achievements of the Ludlow Research Group.*
Mr. V. G. Walmsley.—*The Usk area.*
Dr. J. D. Lawson.—*The Aymestry area.*
Mr. C. H. Holland.—*The Knighton area.*
Mr. J. H. Price.—*Ludlow of the Llandovery area.*
Dr. S. H. Straw.—*Summary.*

September 5

Geographical distribution of past floras, Presidential Address by Mr. W. N. Edwards.
Marine organisms and biogeochemistry. (See entry under Section D.)
Geology and civil engineering with special reference to soil mechanics. (Joint session with Section G (Engineering)) :
Mr. F. H. Edmunds.—*Geology and site investigations.*
Mr. P. L. Capper.—*The fundamentals of soil mechanics.*
Mr. A. H. Toms.—*Soil mechanics and railway civil engineering.*
Mr. F. D. C. Henry.—*Soil mechanics aspect of the design of foundations.*

September 6

On the geology of East Greenland:
Prof. W. F. Whittard.—*General introduction.*
Dr. D. T. Donovan.—*Mesozoic stratigraphy of East Greenland.*
Mr. J. W. Cowie.—*The Lower Palaeozoic of Greenland.*
Mr. J. D. Peacock.—*The geology of Dronning Louise Land, N.E. Greenland.*
The geology of North Devon:
Mr. R. Goldring.—*Sedimentation in the Upper Devonian and Lower Carboniferous of N. Devon.*
Dr. Scott Simpson.—*Some trace fossils.*
Mr. D. J. Shearman.—*Faulting in North Devon and its influence on the drainage.*
Dr. W. R. Dearman.—*The structure of the Culm on the border of Dartmoor near Okehampton, N. Devon.*
Dr. A. G. Lowndes.—*Tracer minerals and the western approaches to the English channel.*
Mr. I. H. Ford.—*Radioactive studies of some Cornish rocks.*

September 7

Dr. Gwyn Thomas.—*The palaeo-ecology of Old Red Sandstone fossils from S. Wales.*
Mr. W. T. Dean.—*The trilobites of the type Caradocian series.*
Dr. M. T. Te Punga.—*Periglacial geology in Southern England.*
Dr. T. P. Burnaby.—*The distribution of foraminiferal species with respect to commonness in some fossil and recent faunas.*
Mr. F. M. Taylor.—*Variation in the structure of some colonial Rugose Corals from the Avonian of Derbyshire.*
Mr. P. H. Shelford.—*Some aspects of New Town geology.*

SECTION D

Zoology

September 1

Immunity and development, Presidential Address by Prof. F. W. Rogers Brambell, F.R.S.:
Immunity and development (contd.).
Prof. B. P. Medawar, F.R.S.—*Zoological implications of the phenomenon of tolerance.*
Mrs. R. M. Clayton.—*Differentiation in the embryo and the development of tissue specificity.*

Prof. E. C. Amoroso.—*The endocrine environment of the foetus.*

Dr. N. A. Mitchison.—*Hereditary differences revealed by immunological and related methods.*

Dr. G. E. H. Foxon.—*Radiographic methods in zoological research.*

Dr. E. J. Ambrose and Dr. M. Abercrombie.—*Studies of the behaviour of living cells by a new colour filming method.*

Films illustrating and introducing *Social behaviour of vertebrates.*

September 2

Social behaviour of vertebrates:

Dr. W. H. Thorpe, F.R.S.—*The present state of the evidence for imprinting, with special reference to birds.*

Dr. S. A. Barnett.—*Societies of wild rats.*

Dr. M. R. A. Chance.—*The social relationships of sub-human primates.*

Genetics and medicine. (Joint Session with Sections I (Physiology) and J (Psychology).

Dr. H. Grüneberg.—*Inherited diseases in animals as a tool in medical research.*

Dr. J. A. Fraser-Roberts.—*Causation in mental deficiencies.*

Dr. Eliot Slater.—*Heredity in neurosis.*

Prof. L. S. Penrose, F.R.S.—*Mutation and parental age.*

Dr. G. O. Carter.—*Genetic diseases and child health.*

Migration.

Dr. R. C. Rainey, Miss Z. Waloff and Mr. H. J. Sayer.—*Recent data on movements of desert locust swarms.*

Mr. T. A. Stuart.—*Local migrations of brown trout.*

Dr. G. V. T. Matthews.—*The sun's rôle in bird navigation.*

September 5

The importance of larval characters in classification:

Dr. F. I. van Emden.—*The importance of larval characters for taxonomy in insects.*

Dr. Isabella Gordon.—*The importance of larval characters in the classification of higher crustacea.*

Dr. Sheila M. Willmott.—*The importance of larval characters in the classification of helminths.*

Mr. D. Poynter.—*The classification of nematodes parasitising horses, using larval characteristics.*

Marine organisms and biogeochemistry. (Joint Session with Sections B (Chemistry) and C (Geology):

Dr. J. D. H. Wiseman.—*The rate of accumulation of nitrogen and calcium on the equatorial Atlantic floor.*

Mr. T. M. W. Strong.—*Iron bacteria as rock-forming organisms.*

Dr. H. J. M. Bowen.—*The biogeochemistry of strontium.*

Geographical speciation:

Dr. J. S. Huxley, F.R.S.—*Historical survey and introduction.*

Dr. C. B. Rees.—*Clines in the copepod,* Calanus finmarchicus *in Northern Seas.*

Dr. Ethel Trewavas.—*Geographical speciation in fishes.*

September 6

Animal movement. (See entry under Section I.)

Heredity and the structure of DNA. (See entry under Section A.)

The natural history of estuaries:

Dr. H. A. Cole and Dr. R. H. Millar.—*Shellfish culture in France.*

Mr. F. T. K. Pentelow.—*The elver fishery in the River Severn.*

Prof. J. E. Webb.—*The ecology of tropical marginal lagoons.*

Mr. N. A. Holme.—*Life on sandy shores.*

Dr. J. A. Kitching.—*Life at high pressures.*

Dr. A. G. Lowndes.—*The density of protoplasm as the primary cause of organic evolution.*

Prof. J. Brontë Gatenby.—*Electron microscope study of the contractile vacuole.*

Zoological films.

September 7

Dr. W. E. Ripper.—*The influence of pesticides on the balance of arthropod population.*

SECTION E

Geography

September 1

Prof. W. W. Jervis.—*The city of Bristol in its geographical setting.*

Mr. F. Walker.—*Recent changes in the economic geography of Bristol.*

Dr. F. G. Hannell.—*Climatic fluctuations in Bristol.*

September 2

Mr. J. W. Birch.—*Two aspects of pioneering in Canada.*

Report of Committee on Glossary of Geographical Terms.

Geography and its history, Presidential Address by Mr. J. N. L. Baker.

Mr. O. D. Kendall.—*Geomorphology of the Bristol district.*

Prof. S. W. Wooldridge, C.B.E.—*Some problems of the physiography of the Bristol district in the light of the physical history of south-east England.*

Prof. M. Proudfoot.—*The fragmented administrative structure of Chicago.*

September 5

Prof. Niels Nielsen.—*The organsiation of geographical researches in Northern Slesvig.*

Mr. K. Clayton.—*The glacial succession in Essex and the associated morphological features.*

Mr. J. C. Pugh.—*The erosional significance of cyclic bevelling in a Savana landscape.*
Prof. W. J. Varley.—*The zonation of vegetation and rainfall in the Gold Coast.*
Dr. J. B. Tait.—*The Atlantic current in the Faroe-Shetland channel.*
Mr. F. Kingdon-Ward, O.B.E.—*Sino-Himalaya and the distribution of plants in South-east Asia.*

September 6

Prof. A. A. Davies.—*The last voyage of John Cabot.*
Mr. G. B. G. Bull.—*Thomas Milne's land utilisation map of the London area in 1800.*
Mr. D. J. M. Hooson.—*The rise and fall of the Chiltern straw industry during the nineteenth century.*
Miss Hilary C. Chew.—*Some major changes in regional types of farming in England and Wales, from the 1930s to the 1950s.*
Dr. R. H. Osborne.—*Internal migration in England and Wales, 1951.*

September 7

Dr. Colin Bull.—*The Greenland ice-sheet.*
Mr. H. Lister.—*Regime of the Greenland ice-sheet.*
Mr. P. J. Wylie.—*Stages of ice recession in Dronning Louise Land.*

SECTION F

Economics

September 1

Mr. K. S. Lomax.—*Trends in production and productivity.*
Dr. F. A. Wells.—*Productivity in the firm.*

September 2

The Economic foundation of wage policy, Presidential Address by Prof. J. R. Hicks.
Mr. S. R. Wragg.—*Measurement of efficiency in agriculture.* (Joint session with Section M (Agriculture).)

September 5

Mr. H. A. Turner.—*Social determinants of wages.*
Mr. K. J. W. Alexander.—*Wages in coal mining since nationalisation.*
Dr. N. S. Ross.—*Incentives and productivity.*

September 6

Mr. F. R. Eels.—*The economics of shift working.*
Mr. I. F. Gibson.—*The rationalisation of wages—a case study.*
Mr. F. A. Cockfield.—*The report of the Royal Commission on the Taxation of Profits and Income.*

September 7

Mr. J. D. Chambers.—*Population change and the economy in the eighteenth century: a regional study based on parish registers.*

SECTION G

Engineering

September 1

The influence of the engineer on sea transport and trade, Presidential Address by Dr. S. F. Dorey, C.B.E., F.R.S.
Mr. M. W. Rosen.—*The influence of space flight on engineering and science.*

September 2

Session A

Dr. R. W. L. Gawn.—*Model research and its application to ship design.*
Mr. J. S. Tritton and Mr. J. C. C. Paterson.—*The scientific development of modern locomotive designs.*

Session B

Dr. J. V. Dunworth.—*The methods of using fuel in a nuclear power programme.*
Mr. H. H. Gott.—*The design and operation of power producing reactors.*

September 5

Session A

Mr. J. A. Proudlove.—*Motorways.*
Mr. J. N. McHattie.—*Motor vehicles and design.*

Session B

Mr. C. W. Miller.—*The linear acceleration of charged particles to high energies.*
Dr. J. B. Adams.—*Circular accelerators for nuclear particles.*
Geology and civil engineering with special reference to soil mechanics. (Joint Session with Section C (Geology)):
Mr. F. H. Edmunds.—*Geology and site investigations.*
Mr. P. L. Capper.—*The fundamentals of soil mechanics.*
Mr. A. H. Toms.—*Soil mechanics and railway civil engineering.*
Mr. F. D. C. Henry.—*Soil mechanics aspect of the design of foundations.*

September 6

Session A

Mr. Peter G. Masefield.—*Recent progress in British air transport.*
Dr. W. J. Strang (paper presented by Dr. A. E. Russell).—*Effects of turbine engines on civil air-transport design.*

Session B

Papers by Young Engineers :
Mr. D. L. Brook.—*The effect of leakage on compression and expansion in a non-flow process.*
Dr. J. E. Gibson.—*A mathematical and photo-elastic investigation of the stress distribution under foundations.*
Mr. D. Howe and Mr. K. H. Griffin.—*Constraint effects in box beams.*

SECTION H

ANTHROPOLOGY AND ARCHAEOLOGY

September 1

Anthropology : a scientific unity ? Presidential Address by Dr. D. B. Harden.

Regional archaeology :

Dr. E. K. Tratman, O.B.E.—*The archaeology of the Bristol region.*

Mr. H. St. George Gray.—*The Lake villages of Somerset.*

Scientific techniques applied to archaeology :

Mr. L. Biek.—*Scientific evidence from burials.*

Dr. E. K. Tratman, O.B.E.—*Teeth and archaeology.*

Dr. Stuart Young.—*The Oxford University Research Laboratory for archaeology and the history of art.*

September 2

Disposal of the dead, and beliefs regarding the after-life (General theme) :

The earliest evidences :

Dr. K. P. Oakley.—*Earliest evidence of disposal of the dead.*

Mr. M. C. Burkitt.—*Middle and Upper Palaeolithic burials.*

Dr. L. H. Wells.—*Burial customs and the human palaeontology of Pre-Neolithic Britain.*

Evidence from social anthropology :

Mr. R. Berndt.—*Cannibalism in the eastern Central Highlands of New Guinea.*

Dr. J. Goody.—*Death and social control among the Lo Dagaa of the Gold Coast.*

Mr. G. W. B. Huntingford.—*Nandi beliefs in a future life.*

September 5

General theme (continued from Friday) :

Evidence from American archaeology and Japanese anthropology :

Mr. Hitoshi Watanabe.—*Disposal of the dead by the Ainu of Japan.*

Mr. Adrian Digby.—*Burial and the After-Life among the Maya.*

Dr. G. H. S. Bushnell.—*Disposal of the dead in ancient Peru.*

Dr. Margaret Murray.—*Primitive burial customs and beliefs in the future life in ancient Egypt.*

September 6

General theme (continued from Monday) :

The evidence from the British Isles :

Dr. H. N. Savory.—*Communal and separate burial in Neolithic Britain.*

Mr. L. V. Grinsell.—*Inhumation and cremation in the British Bronze Age, and related beliefs.*

Prof. I. A. Richmond.—*Iron Age and Romano-British beliefs in the after-life.*

Dr. H. R. E. Davidson.—*Funeral symbolism in Anglo-Saxon England.*

Miss V. Alford.—*Song and dance in connection with funerals in Europe.*

September 7

General theme (concluded) :

Mr. L. V. Grinsell.—*The survival and recurrence of primitive funerary customs and beliefs in recent times.*

Summing up and concluding remarks by Rev. Prof. E. O. James.

SECTION I

PHYSIOLOGY

September 1

Dust and health in industry :

Dr. B. M. Wright.—*Measurement of dust exposure.*

Prof. J. Gough and Dr. A. G. Heppleston.—*The harmful effects of pneumoconiosis.*

Mr. S. Smith.—*Protection against the inhalation of industrial dust.*

Dr. R. S. F. Schilling.—*Respiratory disease among cotton workers.*

September 2

Genetics and medicine. (See entry under Section D.)

Cerebral activity. (Joint Session with Section J (Psychology)) *:*

Dr. C. G. Phillips.—*Nerve cells.*

Dr. W. Grey Walter.—*Electrical signs of mental function.*

Dr. D. M. MacKay.—*Towards an information-flow model of cerebral organisation.*

Mr. M. F. Piercy.—*The behavioural study of cerebral dysfunction.*

September 5

The sensory pathway, Presidential Address by Dr. R. S. Creed.

Dr. G. Gordon.—*The sensory pathway from the skin.*

Dr. I. C. Whitfield.—*The nervous mechanism of hearing.*

September 6

Animal movement. (Joint Session with Section D (Zoology)) :

Mr. M. A. Sleigh.—*Co-ordination and movement of cilia.*

Dr. T. Weis-Fogh.—*Flapping flight of insects.*

Dr. R. H. J. Brown.—*Flapping flight of birds.*

Dr. O. C. J. Lippold.—*Fatigue in human voluntary movement.*

September 7

Lighting and vision :

Mr. H. C. Weston.—*Studies of human responses to varieties of lighting ; their influence upon concepts of good practice.*

Mr. W. R. Stevens.—*The relation between visual acuity, luminance and size of surround.*

Dr. W. F. Floyd.—*Some effects of filament and of fluorescent lighting on visual performance.*

Mr. J. G. Holmes.—*Lighting and the visual confidence of road users.*

SECTION J

PSYCHOLOGY

September 1

Mr. W. A. McElroy.—*Personality and the dislike of shades of green and brown.*

Mr. K. F. H. Murrell.—*The work of a university research unit.*

Prof. T. H. Pear.—*The social psychology of speaking.*

The effective use of manpower, Presidential Address by Mr. Alec Rodger.

The work of psychologists in the public services in the south-west of England :

Mr. S. Griew.—*The psychologist in an industrial rehabilitation unit.*

Mr. R. V. Saunders.—*The psychologist in the child guidance service.*

Mr. G. B. Todd.—*The psychologist in the approved school.*

Mr. J. H. Fitch.—*The psychologist in the prison service.*

Visit to Burden Neurological Institute.

September 2

Genetics and medicine. (See entry under Section D.)

Cerebral activity. (See entry under Section I.)

Mr. D. C. Duncan.—*Tabular methods of recording labour losses.*

Dr. A. Heron.—*The relation between psychological and industrial handicap among unskilled workers.*

Mr. D. Wallis.—*The design of human operating and controlling tasks associated with modern equipment.*

Mr. D. C. Fraser.—*Recent experimental work in the study of fatigue.*

September 5

The contribution of psychoanalysis to the understanding of human behaviour :

The Rev. Prof. J. Nuttin.—*Human behaviour and the psychoanalytic theory of motivation.*

Prof. A. C. T. W. Curle.—*Psychoanalysis and the study of society.*

Dr. C. de Monchaux.—*Motives and thinking.*

Mr. W. D. Furneaux.—*The determinants of success in intelligence tests.*

Mr. R. R. Dale.—*Co-education in secondary schools.*

Dr. M. M. Clark.—*Left-handedness.*

Mrs. B. E. Dockar-Drysdale.—*An experiment in residential treatment of affectionless children.*

September 6

Social and psychological aspects of rehousing :

Dr. H. G. Maule.—*The family.*

Dr. F. Martin.—*The community.*

Dr. G. M. Carstairs.—*The use of psychological tests in anthropological field work.*

Dr. J. Sandler and Mr. V. Rakoff.—*The psychological characteristics of people who blush easily.*

Dr. A. Petrie and Mr. R. A. Willett.—*A comparison of the effects of surgical treatment of pain, epilepsy and mental illness.*

Mr. J. E. Orme.—*Problems of mental disturbance in the aged.*

Language :

Prof. G. P. Meredith.—*Semantics in relation to psychology.*

Prof. S. Ullmann.—*The concept of meaning in linguistics.*

Sir Russell Brain, Bt.—*Semantic aspects of aphasia.*

Dr. F. H. George.—*Semantics, pragmatics and behaviour.*

SECTION K

BOTANY

September 1

Biological organisation, Presidential Address by Prof. K. Mather, F.R.S.

Dr. J. L. Jinks.—*Cytoplasmic inheritance in fungi.*

Dr. J. M. Thoday.—*Hybridity and the organisation of development.*

Miss A. M. Evans.—*The production and identification of polyploids in clovers.*

September 2

Nitrogen metabolism:

Prof. E. W. Yemm.—*Cellular structures and protein synthesis.*

Dr. A. J. Willis.—*The assimilation of inorganic forms of nitrogen.*

Dr. B. F. Folkes.—*The metabolism of amino-acids and the synthesis of proteins.*

Prof. H. E. Street.—*The nitrogen nutrition of excised roots.*

Mr. W. S. Lacey.—*Some Welsh Lower Carboniferous Lycopods.*

Prof. G. Melchers.—*Virus mutability and external conditions.*

Dr. H. Godwin, F.R.S.—*Botanical and geological history of the Somerset Levels.*

September 5

Genetics and plant breeding. (Joint Session with Section M (Agriculture). See also entry under Section M) :

Dr. D. Lewis, F.R.S.—*The genetical approach to plant breeding.*

Dr. G. M. Gaskell.—*Genetical problems in the improvement of Rubus species.*

Dr. A. J. Bateman.—*The control of variability.*

Mr. W. Williams.—*Heterosis concepts and the improvement of crop plants.*

Dr. R. L. Knight, O.B.E.—*The genetical approach to disease resistance in plants.*

Dr. G. H. D. Bell.—*The implication and possibility of organised plant breeding.*

Fungi in forests. (See entry under Sub-section K.*)

Dr. R. A. Couper.—*Supposedly dicotyledonous pollen grains from the Jurassic.*

Dr. H. G. Baker.—*Fritz Müller and pollen dimorphism in the Rubiaceae.*
Mr. W. Gordon Smith.—*Intertidal algal zonation in Western Australia.*
Prof. W. E. Isaac.—*The distribution and ecology of South African marine Siphonales and Siphonocladiales.*
Mr. D. H. N. Spence.—*Vegetation of the serpentine of Unst, Shetland.*

September 6

Heredity and the structure of DNA. (See entry under Section A.)
Trace elements and plant growth. (Joint Session with Section M (Agriculture)):
Prof. T. Wallace, C.B.E., M.C., F.R.S.—*Trace elements in plant nutrition.*
Dr. E. J. Hewitt.—*Problems and methods in establishing the essential nature of trace elements in plants.*
Dr. D. J. D. Nicholas.—*The rôle of molybdenum in the nitrogen metabolism of plants, with particular reference to nitrate reductase.*
Mr. J. W. Hannay.—*The use of excised root cultures in the study of micronutrient problems.*
Mr. T. J. Wallace showed coloured lantern slides of *dune fungi*
Dr. C. F. Sharman.—*Botanical aspects of the tobacco industry.*

September 7

Chalk grassland :
Sir Arthur Tansley, F.R.S.—*The chalk grassland community.*
Dr. J. F. Hope-Simpson.—*An extensive survey : findings and problems.*
Mr. R. M. S. Perrin.—*The genesis of the soils overlying chalk.*
Mr. F. H. Perring.—*Soil factors in relation to history and climate.*
Mr. I. H. Rorison.—*Mineral nutrition experiments with selected species.*

SUB-SECTION K*

Forestry

September 1

Mr. K. G. Stott.—*The cultivation and uses of basket willows.*

September 2

Afforestation and the community, Chairman's Address by Prof. E. C. Mobbs, O.B.E.
Mr. A. H. Popert.—*The place of broadleaved trees in British forestry.*
Mr. C. M. Floyd, O.B.E.—*Hedgerow timber in the west of England.*

September 5

Fungi in forests. (Joint Session with Section K (Botany)).
Dr. I. Levisohn.—*Ways of studying the activity of mycorrhiza-formers in the soil.*
Dr. Lilian E. Hawker.—*Hypogeous fungi.*
Miss R. M. Godfrey.—*Some woodland species of* Endogone.
Prof. C. G. C. Chesters.—*Fungal population of bark of living cells.*

September 6

Mr. D. H. Carstairs.—*Some uses of timber in the aircraft industry.*
Mr. J. R. Aaron.—*Timber in river and sea defence works.*
Mr. Edward Barnsley.—*The use of timber by craftsmen furniture makers.*

SECTION L

Education

September 1

The place of the junior school in education today : its aims, objects and achievements :
Miss D. Dymond.—*The junior school—past and present.*
Mr. J. Scott Wilkie.—*The junior school : looking ahead.*

September 2

The educated man in 1955, Presidential Address by Mr. J. F. Wolfenden, C.B.E.
Mr. P. H. K. Kuenstler.—*The youth service.*
Man and his machines :
Sir Ben Lockspeiser, K.C.B., F.R.S.—*New concepts of science and advanced industrial techniques.*
Mr. Harry Ree.—*Automatic control in industry and its effect on the schools.*
Dr. J. E. Richardson.—*Training of technicians for the automatic age.*

September 5

The training of the physicist. (See entry under Section A.)

September 6

The teaching of chemical principles in school and university. (See entry under Section B.)
The improvement of reading :
Mr. R. T. Strayton.—*Demonstration of methods of increasing reading efficiency.*
Dr. M. D. Vernon.—*Reading to remember.*

September 7

Dr. J. Bronowski.—*The educated man in 1984.*

SECTION M

Agriculture

September 1

Utilisation and evaluation of grassland:
Mr. R. A. Hamilton.—*Utilisation of grassland.*
Mr. C. Line.—*Measuring the output of leys with the milking cow.*
Dr. C. C. Balch.—*The nutritive value of grass silage.*

September 2

The impact of education on farming, Presidential Address by Mr. W. B. Mercer, C.B.E.

Mr. E. M. Owens.—*Intensive grass production for milk.*

Measurement of efficiency in agriculture. (See entry under Section F.)

September 5

Genetics and plant breeding. (See entry under Section K.)

Fertility in farm animals:

Dr. J. A. Laing.—*The standard of fertility in livestock.*

Dr. J. Hammond, C.B.E., F.R.S.—*Factors enhancing fertility.*

Mr. A. F. Holt.—*Factors decreasing fertility levels.*

September 6

Trace elements and plant growth. (Joint Session with Section K (Botany)):

Dr. D. P. Cuthbertson.—*Trace element deficiencies in stock.*

Dr. Ruth Allcroft.—*Industrial fluorosis in farm animals.*

ASSEMBLY OF CORRESPONDING SOCIETIES

September 1

The fragmentation of science, Presidential Address by Mr. P. Ritchie Calder, C.B.E.

September 2

Field study by schools :

Mr. R. S. Cormack.—*The head plumage of house sparrows.*

Miss F. Scott.—*Freshwater biology.*

Mr. J. J. Swift.—*The Charterhouse nest-box scheme.*

Miss M. Silcocks.—*Owl pellets.*

September 5

Dr. F. G. Hannell.—*The British Schools' Exploring Society's 1951 expedition to central Iceland.*

Dr. H. E. Lewis and Mr. P. F. Taylor.—*Photography in the Arctic.*

Mr. C. L. Boltz.—*The West Country's historical contribution to science.*

September 6

Dr. W. E. Swinton.—*The city amateur, his place and prospects.*

Prof. A. Messervy.—*Veterinary education in the university of Bristol.*

REFERENCES TO PUBLICATION OF COMMUNICATIONS TO THE SECTIONS
AND OTHER REFERENCES SUPPLIED BY AUTHORS

The titles of discussions, or the names of readers of papers, as to which publication notes have been supplied, are given below in alphabetical order under each Section.

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Section A

Barton, Dr. A. W. To appear in *Adv. of Science*.

Boyd, Dr. R. L. F. Cf. 'Rocket Exploration of the Upper Atmosphere.' Edited by Boyd, Seaton and Massey. (Pergamon Press, London, 1954.); and Boyd, R. L. F., 'Rocket Research in the Upper Atmosphere.' *Science Progress*, **167**, pp. 435–448 (1954); 'Research by Rockets.' *Discovery*, July 1955; 'Great Things from Little Satellites.' *Listener*, August 11, 1955, p. 205; 'Study of Solar Radiation at High Altitudes using Rocket Borne Instruments.' *Proc. Roy. Soc.*, shortly to be published; 'British Plans for Upper Atmosphere Rocket Research.' *Discovery*, shortly to be published; 'Upper Atmosphere Research by Rockets.' *Times Science Supplement*, shortly to be published.

Cosslett, Dr. V. E. *Research*, **8**, 48–56 (1955).

Cottrell, Dr. A. H. Abstract to appear in *Electrical Times*.

Davidson, Prof. J. N. Cf. 'The Biochemistry of the Nucleic Acids.' By J. N. Davidson. 2nd edition. 1953. (Methuen, London 1953.)

'The Nucleic Acids: Chemistry and Biology.' By E. Chargaff & J. N. Davidson (Editors). 2 volumes. (Academic Press, New York 1955.)

Dunworth, Dr. J. V. To appear in *Engineering*; cf. also Paper No. 403, Geneva Conference on the peaceful applications of atomic energy, August 1955.

Flames and Combustion, *Nature*, **176**, No. 4486, 771–2.

Kendall, D. G. Cf. 'Deterministic and stochastic epidemics in closed populations.' To appear in *Proc. 3rd Berkeley Symposium on Math. statistics and probability*. (Univ. of California Press.)

Morris, Sir Philip. To appear in *Advancement of Science*; cf. also *British J. Appl. Physics*, **1**, No. 1 (January 1950).

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Mullins, Dr. B. P. Summary published by Inst. of Fuel; for full refs. apply B.A. office.

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Thackeray, D. P. C. Cf. 'Image Converter Tubes and their Application to High Speed Photography.' J. S. Courtney-Pratt. *Phot. J.*, **92B** 137–48 (1952); 'Fast Multiple Frame Photography.' J. S. Courtney-Pratt, *J. Phot. Sci.* **1**, 21–40 (1953); 'A High Speed Cine Microscope.' J. S. Courtney-Pratt. (Paper read to 2nd International Congress on High Speed Photography, Paris, 1954, in the Press); 'Fast Multiple Frame Photography by Cathode Ray Tube Illumination.' J. S. Courtney-Pratt and D. P. C. Thackeray. (Paper read to 2nd International Congress on High Speed Photography, Paris, 1954, in the Press).

Thring, Prof. M. W. *Electrical Times*, **128**, No. 3331, 354; *J. Inst. Fuel*, **28**, No. 177, 526; 'Proposals for the Establishment of an International Research Project on Luminous Radiation.' M. W. Thring. *BISRA Report P/N. 40*, November 1948; 'Preliminary Technical Proposals for a Comprehensive Scheme of Research on Luminous Radiation.' M. W. Thring. *BISRA Report P/N. 41*, December 1948; 'Research on Flame Radiation—The plan of an attempt to fill in an important gap in Fuel Technology.' M. W. Thring. *Fuel*, **29**, 173 (1950); 'Physics in the Iron and Steel Industry' (No. 9 in series). The BISRA Physics Laboratories; Work in progress at Battersea, London. *Iron and Coal Trades Review*, **161**, No. 17 (1950); 'Investigation of Flame Radiation.' Results of International Research Group using an Experimental Furnace at Ijmuiden, Holland. By G. M. Ribaud, J. E. de Graaf, O. A. Saunders and M. W. Thring. *Iron and Coal Trades Review*, November 30, 1951, 1181; 'Flame Radiation Research Joint Committee—Reports of the 1949 Trials at Ijmuiden.' Reprinted from *The Journal of the Institute of Fuel*, November 1951 and January 1952. Nos. 24 and 25; 'Action des Variables principals sur les Pseudo-Facteurs d'Emission de la Flamme.' L. F. Daws and M. W. Thring. Comite International d'Etudes sur le Rayonnement des Flammes. *Extrait de Chaleur et Industrie*, No. 328, pp. 387–92, November 1952; 'The Effect of Emissivity and Flame Length on Heat

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ERRATA

In the paper entitled "Sewer Rat Populations and Their Control," by Dr. E. W. Bentley, in *The Advancement of Science* of June, 1955, on p. 112, right-hand column, 10 lines from the bottom, the text should read: 'it is *likely* that the animals in the colony . . .'

In the Presidential Address entitled "The Effective Use of Manpower," by Mr. Alec Rodger, in *The Advancement of Science* of September, 1955, the following changes should be made: p. 239, right-hand column, 4 lines from bottom, delete 'to be' between 'often' and 'found'; p. 248, left-hand column, 12 lines from bottom, insert (1955) after Wootton and on p. 249 at the end of references insert: 'Wootton, B. (1955): *The Social Foundations of Wage Policy*. London, Allen and Unwin.'

Printed in Great Britain
Spottiswoode, Ballantyne & Co. Ltd.
London & Colchester